R. A. SKELTON & CO.
STEEL & ENGINEERING, LTD.

STEEL CONSTRUCTION

HANDBOOK NO. 22

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Telegrams:

HANDBOOK No. 22. Fourth Edition, 1948.

STEEL CONSTRUCTION

AND

BROAD FLANGE BEAMS, GREY PROCESS.

R. A. SKELTON & CO.,

STEEL & ENGINEERING, LTD.

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See also special code words herein.

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INTRODUCTION.

1. CONTENTS.

This book is a revised edition of our Handbooks 20 and 21, now combined in a single volume.

2. FORMULÆ.

As the British Standard Specification for column stresses is now so widely used, we have recalculated the safe-load tables, column bases, etc. in accordance therewith. Those who may prefer Fidler's formula will find the safe stresses tabulated on page 95, and the corresponding safe loads in previous handbooks (also in booklet C.619/B).

3. WELDING.

This chapter has been enlarged and rewritten to accord with current practice.

Designers are rightly advised to "forget normal design" with their new medium; but should remember that it is far from economical to use girders welded up from plates in substitution for plain rolled steel shapes. The saving in weight thereby achieved may be altogether outweighed by the costly workmanship involved.

4. BROAD FLANGE BEAMS, GREY PROCESS.

A concise statement of the uses and advantages of these sections will be found on pages 7–13.

As may be seen from the list of sizes on pages 16–20, and the notes thereto on page 21, the various sections are rolled in four standard weights—known as the DIE, DIL, DIN, and DIR series—and can also be rolled to intermediate weights, of which some typical examples (marked *i*) are included in the aforementioned list of sizes.

5. SPECIAL SECTIONS.

In addition to the foregoing, two special series are rolled at the Differdange works:—

(a) Seven sections, from 4″ to 8″, with extra wide flanges, specially

INTRODUCTION.—Continued.

designed for use as poles or masts. Their sizes and properties are tabulated separately on page 20 and elsewhere.

(b) Four sections, 6″ × 6″, 8″ × 8″, 10″ × 10″, and 12″ × 12″, in American weights. Their dimensions and properties are tabulated separately on page 22.

6. BRITISH STANDARD SECTIONS.

The tabulated British sizes of Joists, Channels, Angles, and Tees are the British Standard sections as at the date of compilation.

In addition to the usual data (dimensions, properties, and safe loads), we include details of suitable end connections and separators, current extras, etc.

7. AMERICAN AND METRIC SECTIONS.

The sizes and properties of American standard Joists and Channels, and of Continental Joists, Channels, and Angles, will be found in the appropriate chapters.

8. ACKNOWLEDGMENTS.

We are indebted to the British Standards Institution for permission to make extracts from a number of their specifications: those cited are obtainable, at prices ranging mostly from 2/- to 5/- each, from the Institution's head office, 28 Victoria Street, London, S.W.1.

9. COPYRIGHT.

R. A. SKELTON & Co.,
Steel & Engineering, Ltd.

London,
February, 1948.

(For notes to fourth edition, P.T.O.)

Notes to Fourth Edition.

In order to bring this handbook more up to date, the chapters on Metal Arc Welding and Extras have been substantially altered and other minor corrections made.

BRITISH STANDARD SPECIFICATION 449 (1937). Under the War Emergency Revision, still in force pending revision of this specification, the following maximum working stresses are allowed.

Tension and compression in beams, 10 tons per square inch (extreme fibre). Where the compression flange of a beam is not supported laterally, and the unsupported length exceeds 20 flange widths, the stress is reduced to $14 \cdot 4 - \cdot 22L/B$.

A beam which has its compression flange within the depth of a concrete floor, or which receives sufficient lateral support from the transverse members, may be regarded as laterally supported.

Grillage Beams.—The working stress may be increased by 20% for tension and compression flanges of beams, 50% for shear, bearing, and tension (axial) stress, and $33\frac{1}{3}$% for high tensile steel. B.S.S. 449, clause 11, is otherwise unaltered.

Filler Floor Beams.—The stress is increased from 9 to 11 tons per square inch for mild steel, and the stress calculated on the beams alone may be increased to $11 + t$, provided that t (/) the concrete thickness above the top flange is not taken as more than 3 inches.

Other Encased Beams.—The working stress is increased from $8 \cdot 5$ to $10 \cdot 6$ tons per square inch.

Stresses Due to Wind.—For the stresses mentioned above, a further increase of 25% is allowed where the increased stress is induced solely by wind pressure. But no such further increase is allowed in the case of grillage beams and filler floor beams.

BROAD FLANGE BEAMS, GREY PROCESS.

These sections are regularly rolled and readily obtainable at present (Feb., 1948) in about 2 to 4 months from receipt of order, but preliminary enquiry should be made as to possible import or currency restrictions in the country of destination.

In particular, importations of finished steel into the United Kingdom are at present confined to official channels and severely restricted. Consequently there are at present no stocks in the country.

BROAD FLANGE BEAMS, GREY PROCESS.

ORIGIN AND ADVANTAGES.

It was an Englishman, Henry Grey, who discovered a means of manufacturing rolled steel beams with wide flanges. The first works to install a Grey Mill was the Differdange Steelworks in Luxembourg, in 1902; two years later a similar mill was installed at the Bethlehem works in the United States. So great was the demand for these wide-flanged beams that within a few years the Bethlehem works duplicated their plant; and more recently several other foreign works have undertaken the manufacture on a large scale of similar beams.

A description of the Grey Mill and of its important technical advantages over the ordinary horizontal rolling mill will be found on pages 11–13.

These wide-flanged sections now constitute a substantial proportion of the steelwork of every important building in the United States and on the Continent. For example, in a 26-storey bank building at Antwerp the steelwork consists almost exclusively of Broad Flange Beams rolled at the Differdange Works.

On the Swiss Federal Railways, the poles and other structures supporting overhead conductors are composed in nearly all cases of Broad Flange Beams; and, of 350 railway bridges built between 1918 and 1929, almost all are of Broad Flange Beams embedded in concrete.

These Beams have also been used by many British engineers of the highest standing, and for a great variety of purposes, as may be seen from the list of typical users on page 10.

The fundamental advantages of wide-flanged beams may be briefly stated as follows:—

AS COLUMNS. The smaller sections, ranging from 4″ × 4″ to 12″ × 12″, all of equal height and width, are obviously ideal columns. Even the best of the British Standard Joists compare with them unfavourably. This point is demonstrated graphically in Fig. 1 overleaf, where a comparison between B.F. Beams 8″ × 8″ × 43·6 lb. and R.S. Joists 9″ × 7″ × 50 lb. shows the latter to be slightly weaker, although nearly 15% heavier than the B.F. Beam.

If, instead of the 8″ × 8″ section, we use a B.F. Beam 9½″ × 9½″ rolled to its new minimum weight of 41 lb. per foot, the comparison is still more advantageous to the Broad Flange Beam, showing a gain of 5% in capacity with a saving in weight of 18%.

When the comparison is with *built-up columns*, viz., steel joists or channels with plates riveted to the flanges, the economy and convenience of the Broad Flange Beam are still more obvious, as may be seen from Fig. 2 overleaf.

In the United States, the columns in tall buildings are almost invariably composed of Broad Flange Beams. The fact that each section is now obtainable in a wide range of weights adds greatly to their utility for this class of structure.

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

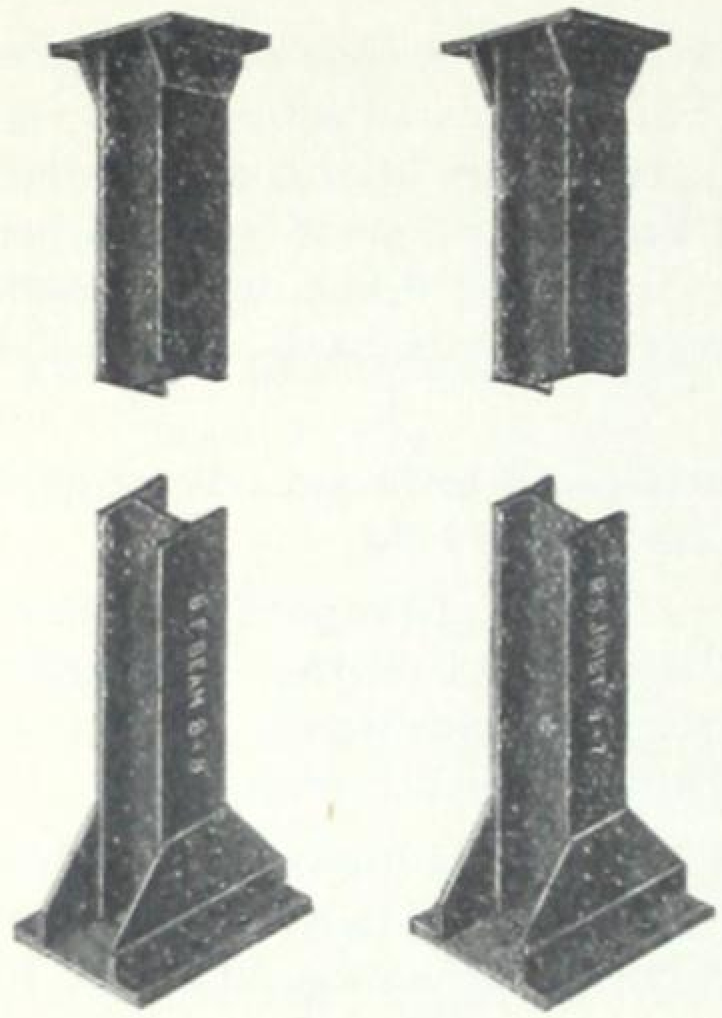

Fig. 1. Stanchion to carry 55 tons.

Height, 16 ft.	B.F. Beam	R.S. Joist
Safe Load ...	57 tons	56 tons
Section ...	8″ × 8″	9″ × 7″
Weight per foot	43·6 lb.	50 lb.
Total weight ...	899 lb.	994 lb.

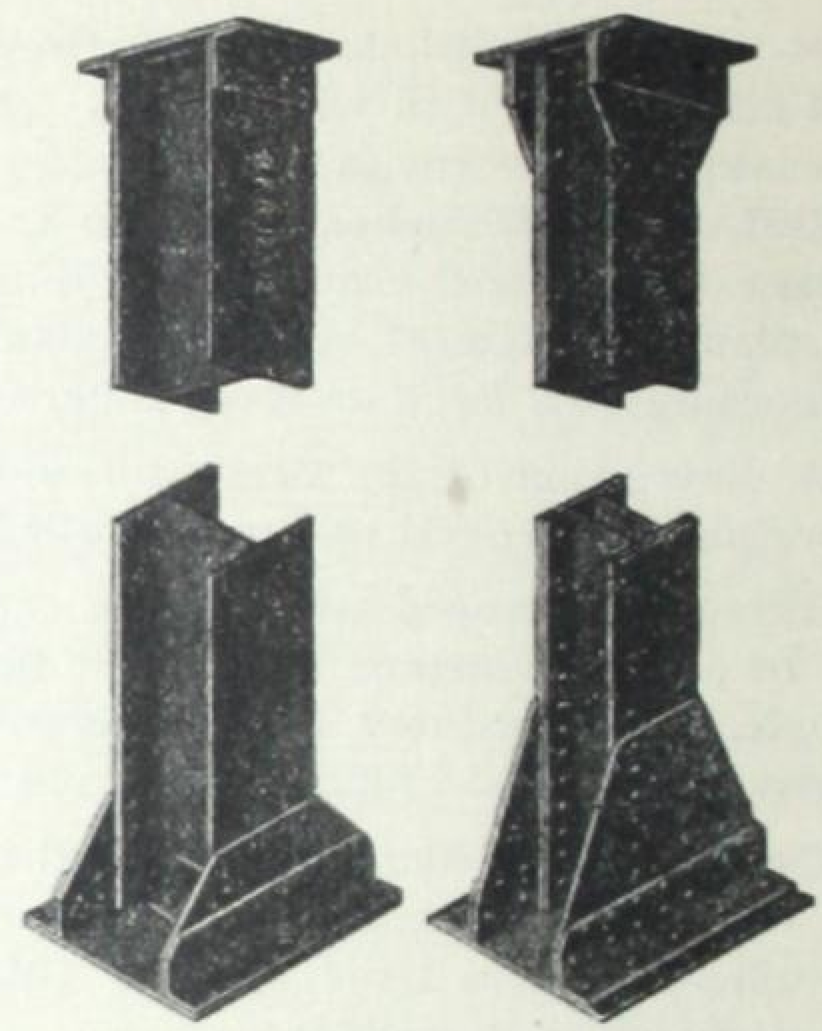

Fig. 2. Stanchion to carry 125 tons.

Height, 16 ft.	B.F. Beam	Comp'nd.
Safe Load ...	127 tons	126 tons
Size	12″ × 12″	9½″ × 10″
Total weight ...	15 cwt.	16·2 cwt.
Rivets ...	90	212

AS BEAMS. For use as beams or girders, Broad Flange Beams *supplement* rather than supplant the ordinary rolled steel joists. That is to say, the use of Broad Flange Beams as horizontal members is chiefly where the span and load are beyond the range of ordinary steel joists. In this connection, it will be observed that the largest British Standard Joist, 24″ × 7½″ × 95 lb., has a section modulus of only 211 (cubic inches), whereas Broad Flange Beams are rolled with 12″ flanges up to 40″ deep, giving any required section modulus, without plating, up to 873 (cubic inches).

It follows that the utility of Broad Flange Beams as horizontal members must be sought primarily in a comparison with the various types of *built-up girders*. As may be seen from Figs. 3, 4, opposite, the plain rolled steel beam shows a great saving in weight and cost; and when the quantity required is at all considerable, a very great saving in *time* also.

Accordingly, Broad Flange Beams of sections 24″ × 12″ to 40″ × 12″ have been employed very extensively in Australia and elsewhere as main girders in *railway bridges* of short span.

Even for light loads, within the capacity of ordinary joists, the use of Broad Flange Beams as girders is definitely indicated in cases where headroom is of particular importance, as, for example, in *theatres* and *subways*; also where lateral stiffness is required, as in *crane runways*; or when, as with some types of flooring, the narrow flanges of ordinary joists do not afford a sufficient bearing.

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

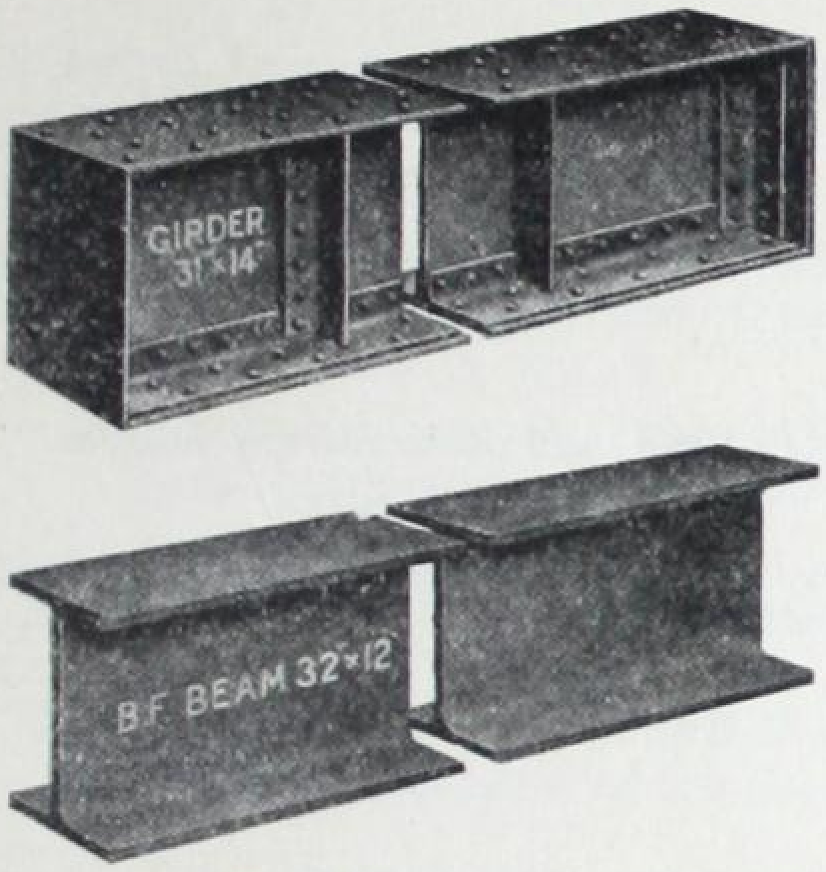

Fig. 3. Replacing a plate girder.

Span, 45 ft.	B.F. Beam	Comp'nd.
Safe Load ...	55 tons	50 tons
Weight of 47′	67 cwt.	87 cwt.
Rivets... ...	Nil	969
B.F. Beam, 32″ × 12″ × 159 lb. (Or use a 28″ × 12″ × 171 lb., weighing 72 cwt.; safe load 52 tons.)		

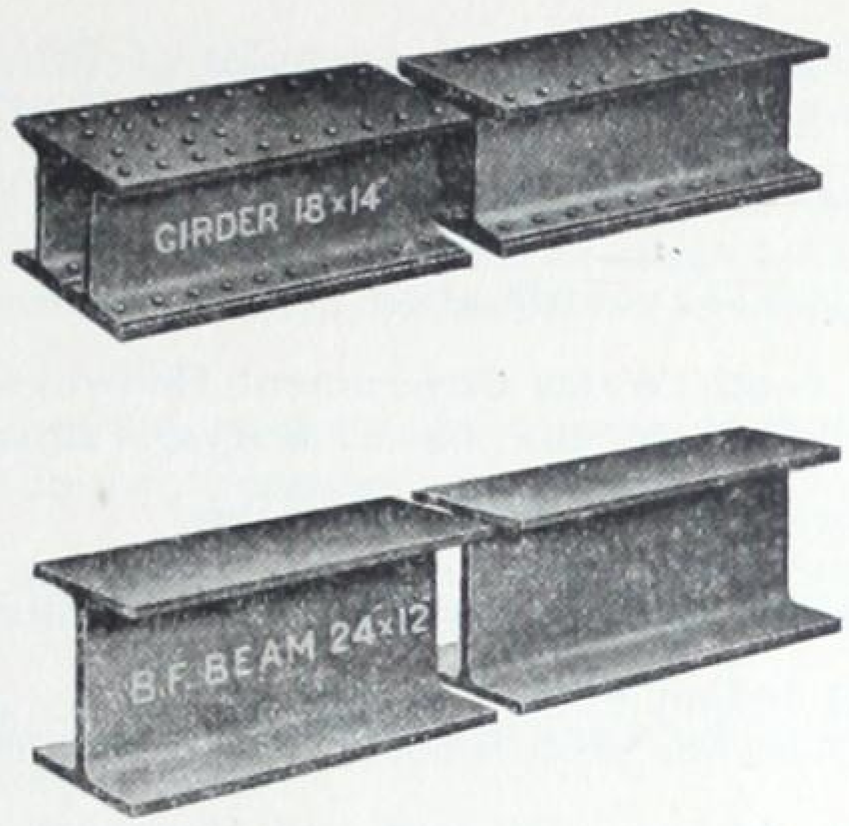

Fig. 4. Replacing a compound girder.

Span, 30 ft.	B.F. Beam	Comp'nd.
Safe Load ...	61 tons	55 tons
Weight of 31′ 6″	43 cwt.	63 cwt.
Rivets... ...	Nil	408
B.F. Beam, 24″ × 12″ × 152 lb. (Or use two 17″ × 12″ × 90 lb.; weight with separators 53 cwt., safe load 54 tons.)		

OTHER USES. The lighter sections of Broad Flange Beams have been extensively employed as poles, etc., supporting overhead cables in South Africa, India, Switzerland and elsewhere. Their advantages for this purpose are explained on pages 154–164. In brief: tubular or latticed poles, though lighter, are considerably more expensive, even in the first instance; while the cost of maintenance is greatly reduced by the diminished liability to corrosion of the solid steel beam and the fact that it can readily be repainted all over.

Broad Flange Beams have been extensively used in Hong Kong, Singapore and elsewhere as piles—in some cases in rolled (*i.e.*, unjointed) lengths of 100 feet and more.

GENERAL ADVANTAGES. Their relative *freedom from corrosion*,* and ease of maintenance, are of course important advantages of solid rolled steel beams in comparison with all types of riveted members. So also are the facilities which the wide flanges, without taper, provide for *sound and simple connections*, whether welded or riveted. The *absence of projecting rivet heads* is often an important advantage, as in beams or stanchions to which crane rails or shafting brackets are to be fixed, and in designing *bedplates for heavy machinery*.

In short, Broad Flange Beams save time, money and weight in steel construction, and greatly facilitate the task of the steelwork designer.

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* These beams can be supplied, when desired, with a copper content, and in the higher tensiles now employed for many purposes. For further details, see "Tests."

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

SOME BRITISH USERS.

The following are examples of British authorities who have used Broad Flange Beams extensively, before and since the Great War—in most cases repeatedly :—

London & North Eastern Railway.
Coal staiths at Hull and Hartlepool ; North Seaton Viaduct, 1924 (280 tons) ; structures for main line electrification.

New South Wales Government Railways.
34″ and 20″ B.F. Beams in Kyogle Bridge (1,015 tons), and other railway bridges.

Victorian Government Railways.
28″ B.F. Beams (600 tons) supporting railway viaduct. These beams freely used also for railway bridges in Queensland and Western Australia.

Great Indian Peninsula Railway.
Main line electrification, 1929, 4,000 tons.

South African Railways and Harbours.
Sections 5½″ to 9½″ as conductor-poles, 1927 (800 tons). Numerous buildings.

Buenos Aires Great Southern Railway.
Short-span bridges.

Mersey Docks and Harbour Board.
Piles, sheds, etc.

New South Wales Public Works Department.
32″ B.F. Beams (4,000 tons) in approaches to Sydney Harbour Bridge, 1927–1931.

Metropolitan Underground Railway, Sydney.
About 4,000 tons, chiefly 32″ and 34″, supporting roads and buildings.

Calcutta Corporation.
2,400 tons supporting 9-million gallon tank.

Dublin Commissioners of Public Works.
Bridges and government buildings.

Brisbane City Council.
520 tons of sections 8″ to 38″ in Grey Street Bridge, 1929.

Crown Colonies.
Various public works in Nigeria, Mauritius, Fiji, Ceylon, etc.

Dominion Bridge Co., Ltd., Montreal.
Various buildings.

The Hong Kong & Kowloon Wharf and Godown Co., Ltd.
Large quantities of B.F. Beams in wharf construction.

Engineers and Architects.
E. S. Andrews, Esq. (Consultant) ; Messrs. Bedingfield & Grundy (Architects) ; O. Bondy, Esq. (Consultant) ; Sir John Burnet & Partners (Architects) ; Messrs. Fox & Mayo (Railway Consultants) ; Messrs. Gelder & Kitchen (Architects) ; A. S. Grunspan, Esq. (Consultant) ; Messrs. Ewen, Harper, Brother & Co. (Architects) ; Messrs. Rendel, Palmer & Tritton (Consultants) ; S. H. White, Esq. (Consultant) ; Messrs. Wilton & Bell (Consultants).

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

THE GREY MILL.

The Grey Process of rolling, as employed at Differdange, comprises three stages, as follows :—

(*a*) The ingot is rolled in an ordinary Blooming Mill, into an "H-shaped" bloom, as shown in Fig. 1 on page 12.

(*b*) The bloom then passes to an Intermediate Mill consisting of two pairs of rolls, shown in Fig. 2.

(*c*) The Finishing Mill, shown in Figs. 3 and 4, consists of two pairs of horizontal rolls and one pair of vertical rolls, in two housings, placed as close together as practicable.

The rolls shown in Fig. 3 bear on the edges of the flanges and determine the flange width.

The horizontal and vertical rolls shown in Fig. 4, determine the depth and thickness of the web, and the thickness of the flanges, respectively.

ADVANTAGES.

The advantages of this process are best realised by comparing with a horizontal mill as used for rolling ordinary rolled steel joists. The finishing pass of such a mill is shown in Fig. 6. The flanges are produced by the plastic metal being squeezed into grooves in the rolls, through pressure exerted on the web.

The difference between the peripheral velocities of the rolls at the points where they bear on the web and on the edges of the flanges respectively, is obviously considerable in the case of a section with deep flanges, and results in the flanges being dragged through the rolls.

Consequently, the quality of the metal in the flanges tends to be inferior to that of the web and there is a tendency to form fissures at the junction between the web and the flanges.

In the *Grey Mill*, on the contrary, both the flanges and the web are formed by direct pressure ; the section is rolled all over and the metal is squeezed together instead of being dragged apart at the junctions between the web and the flanges : the superior finish is very noticeable.

VARIATIONS IN WEIGHT.

In the ordinary horizontal rolling mill, the weight per foot of a section can be increased to a limited extent by spacing the rolls in the manner shown in Fig. 7. It will be observed that the web thickness and flange width are increased by the same amount. It is not possible to separate the rolls in this way by more than $\frac{1}{4}''$, as otherwise fins would be formed.

In the Grey Mill, however, by suitably spacing the independent pairs of rolls shown in Figs. 3 and 4, the section can be varied considerably, not only in web thickness and flange width, but also in depth and flange thickness, as shown in Fig. 5.

The considerable limits within which the various sections can be varied in this way may be seen from the Table of Sizes and Properties on pages 16–20.

THE GREY PROCESS.

THE GREY MILL.

Fig. 1.

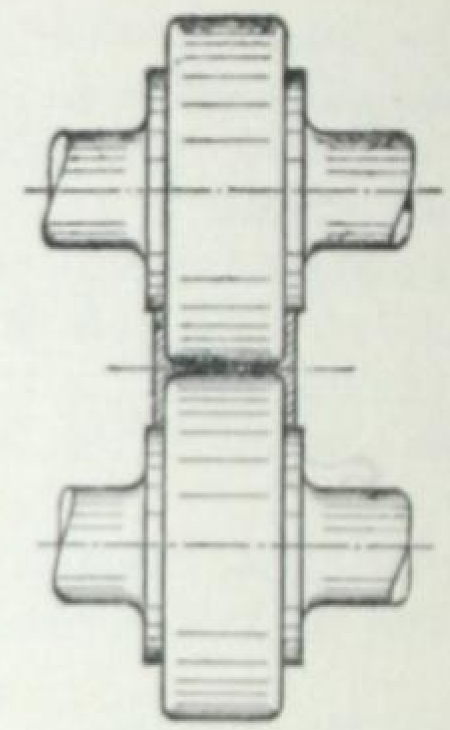


Fig. 3.

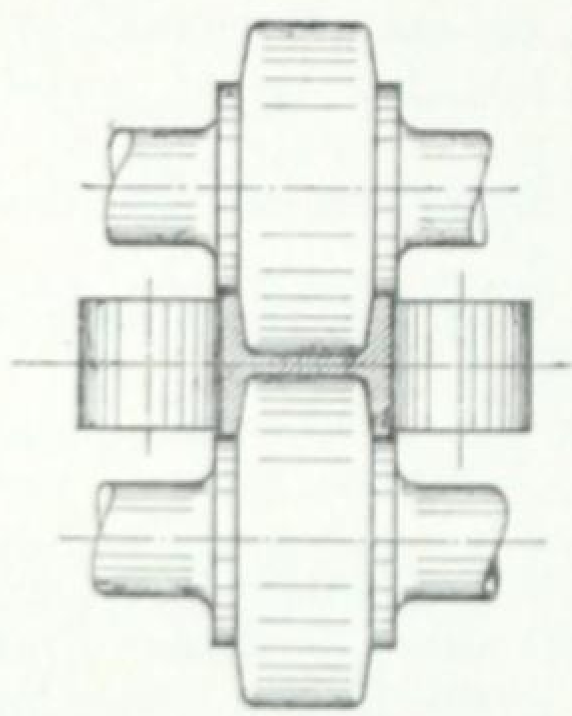


Fig. 2.

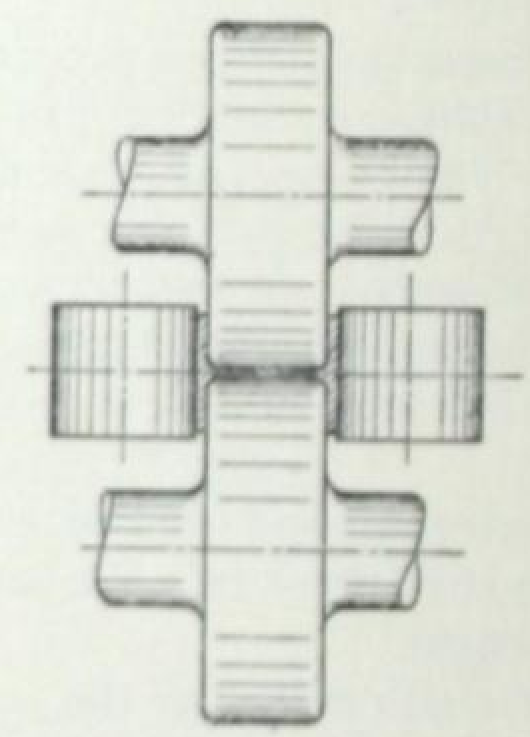


Fig. 4.

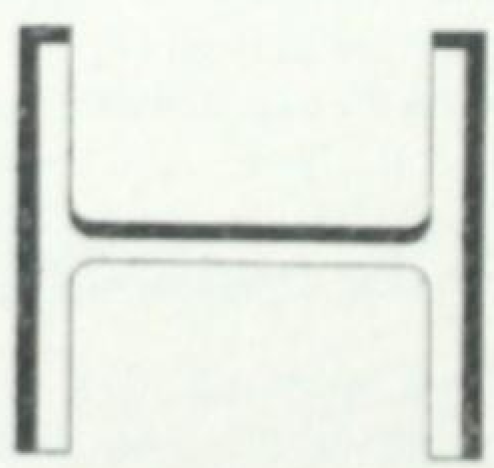


Fig. 5.

HORIZONTAL ROLLING MILL.

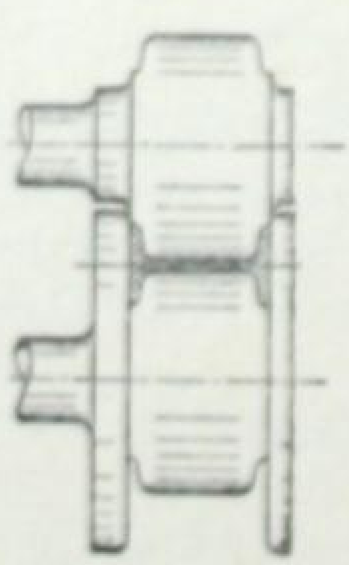


Fig. 6.

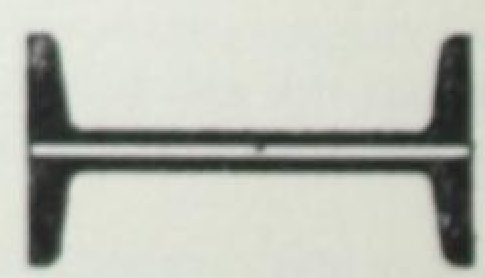


Fig. 7.

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

THE GREY MILL.—Continued.

In addition to the sizes there shown, each section can be rolled to any desired *intermediate* weight. Observe, however, that the ratio of web thickness to flange thickness must be kept constant, for technical reasons. Thus, if we increase the web thickness of the $5\frac{1}{2}'' \times 5\frac{1}{2}'' \times 23 \cdot 4$ lb. section from $0 \cdot 31''$ to $0 \cdot 63''$, we must proportionately increase the flange thickness also, viz., from $0 \cdot 47''$ to $0 \cdot 94''$. It will be apparent from Fig. 5 that the $0 \cdot 32''$ increase in the web thickness will increase the *width* of the section by the *same* amount; and that increasing the flange thickness by $0 \cdot 47''$ will increase the *depth* of the section by *twice* $0 \cdot 47''$.

Accordingly, the dimensions (to one decimal place) will become $6 \cdot 5'' \times 5 \cdot 8''$ (see section YOAGM, page 16).

The simple calculations required for determining the increase in sectional area and moment of inertia will also be apparent from Fig. 5; but, for practical purposes, sufficiently accurate results can be obtained by interpolation.

N.B.—Intermediate and DIR (maximum) weights are not obtainable in smaller quantities than the "minimum lots" tabulated on page 286.

MAXIMUM WEIGHTS.

The ability to produce these sections with greatly thickened webs and flanges is particularly useful—

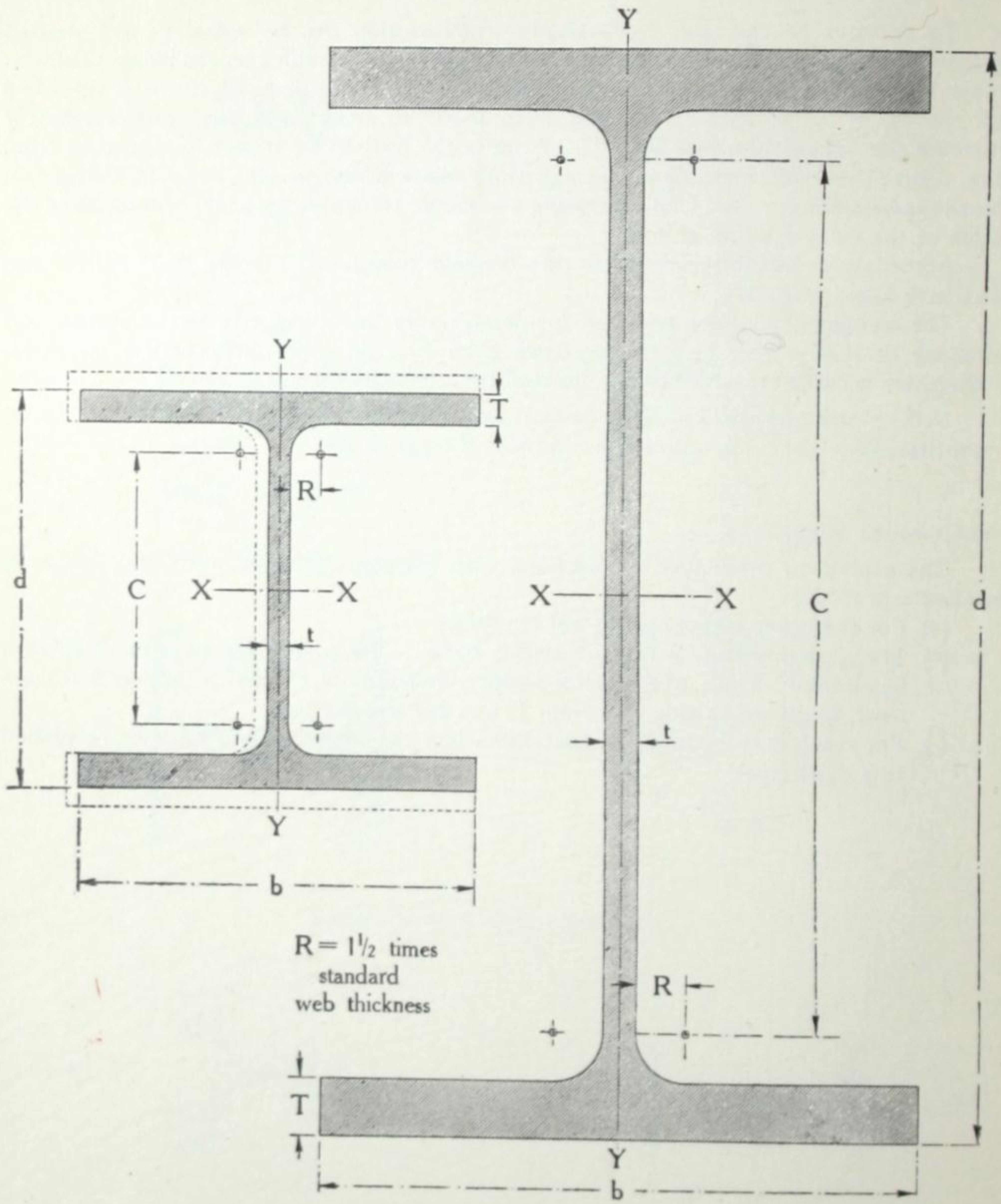
(*a*) For the lower stanchions in tall buildings.

(*b*) For girders which would otherwise have to be plated on account of limited headroom. Thus, in a Bristol factory, 463 tons of the $28'' \times 12''$ section were used, increased in this way from 171 to 201 lbs. per foot.

(*c*) For machinery bedplates, especially when the upper flanges have to be planed to a dead level.

BROAD FLANGE BEAMS, GREY PROCESS.

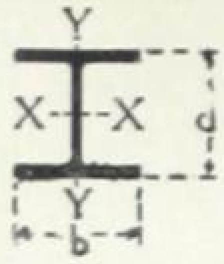
KEY DRAWINGS.



In the smaller drawing the dotted lines indicate the maximum profile (DIR Series).
The values of C (nett depth of web) are tabulated on page 38.

BROAD FLANGE BEAMS, GREY PROCESS.

N.B.—See separate chapters for Safe Loads, Tests, Extras, etc.



SIZES AND PROPERTIES OF
BROAD FLANGE BEAMS, GREY PROCESS.

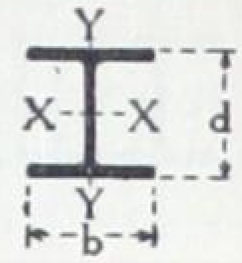
For Explanation, see page 21. For Key Drawings, see page 14.

Nominal Depth.	Dimensions.	Weight per Foot.	Delivery.	Code Word.	Flange Thickness.	Web Thickness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
	d × b				T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.			Ins.	Ins.	Ins.²	Ins.⁴	Ins.⁴	Ins.³	Ins.³	Ins.	Ins.
	3·7×3·9	11·0	*a*	YOOPO	·31	·20	3·2	7·9	3·1	4·2	1·60	1·56	0·98
	3·9×3·9	14·2	*a*	BEAHL	·43	·20	4·2	11·3	4·4	5·8	2·24	1·65	1·03
4	3·9×3·9	14·8	*a*	BAABA	·43	·26	4·4	11·5	4·4	5·8	2·24	1·62	1·01
	4·4×4·1	23·2	*ar*	YOACH	·67	·39	6·8	20·6	7·6	9·3	3·72	1·74	1·06
	4·5×4·7	13·2	*a*	YOOPT	·31	·20	3·9	14·4	5·4	6·4	2·31	1·93	1·18
	4·7×4·7	17·0	*a*	BEANY	·43	·20	5·0	20·4	7·6	8·6	3·22	2·02	1·23
5	4·7×4·7	17·8	*a*	BAANG	·43	·26	5·2	20·7	7·6	8·7	3·22	1·98	1·20
	5·2×4·9	27·9	*ar*	YOADS	·67	·39	8·2	36·0	12·9	13·9	5·31	2·10	1·25
	5·2×5·4	16·4	*a*	YOORY	·33	·22	4·8	24·5	9·0	9·3	3·29	2·25	1·36
	5·5×5·5	21·1	*a*	BEBMO	·47	·18	6·2	35·5	13·2	12·9	4·76	2·39	1·46
5½	5·5×5·5	23·4	*a**	BABAD	·47	·31	6·8	36·6	13·2	13·2	4·82	2·31	1·39
	6·5×5·8	47·9	*ar*	YOAGM	·94	·63	14·1	90·4	31·3	28·0	10·7	2·53	1·49
	5·6×5·8	17·6	*a**	YOOSH	·33	·22	5·2	30·6	11·0	10·9	3·78	2·43	1·46
	5·9×5·9	22·8	*a*	BEBYP	·47	·19	6·7	44·3	16·2	15·0	5·49	2·57	1·56
6	5·9×5·9	24·9	*a**	BABEF	·47	·31	7·3	45·6	16·2	15·4	5·49	2·49	1·49
	6·9×6·2	51·3	*ar*	YOAGT	·94	·63	15·1	111	38·0	32·3	12·2	2·71	1·59
	5·9×6·2	20·0	*a*	YOOTU	·35	·24	5·9	38·1	14·0	12·9	4·58	2·55	1·54
	6·3×6·3	26·3	*a*	BECAK	·51	·20	7·7	58·2	21·3	18·4	6·77	2·74	1·66
6½	6·3×6·3	30·8	*a*	BABHO	·55	·35	9·0	63·3	23·0	20·1	7·32	2·64	1·59
	7·2×6·6	56·0	*ar*	YOAHN	·98	·63	16·5	134	46·8	37·3	14·2	2·85	1·69
	6·8×7·0	24·8	*a**	YOOVI	·39	·26	7·3	62·6	22·2	18·5	6·34	2·93	1·74
	7·1×7·1	31·9	*a*	BEDEM	·55	·22	9·4	89·6	32·7	25·3	9·28	3·09	1·87
7	7·1×7·1	34·7	*a**	BACGE	·55	·35	10·2	92·1	32·8	26·0	9·21	3·01	1·79
	8·0×7·4	63·0	*ar*	YOAJP	·98	·63	18·5	191	65·6	47·9	17·8	3·20	1·88
	7·5×7·8	30·1	*a**	YOOWO	·43	·28	8·8	93·1	33·7	24·9	8·72	3·24	1·95
	7·9×7·9	38·0	*a*	BEIZK	·59	·24	11·2	133	48·1	33·6	12·2	3·44	2·07
8	7·9×7·9	43·6	*a**	BACYL	·63	·39	12·8	143	51·3	36·3	13·1	3·34	2·00
	8·3×8·0	57·5	*ai*	YOHPE	·83	·51	16·9	199	70·5	48·1	17·6	3·43	2·04
	8·7×8·1	71·6	*ar*	YOAMS	1·02	·63	21·1	262	91·2	60·5	22·5	3·53	2·08
	8·3×8·5	34·5	*a*	YOOXS	·45	·29	10·1	133	47·0	32·0	11·0	3·62	2·15
	8·7×8·7	44·6	*a*	BERBE	·63	·26	13·1	189	68·3	43·6	15·7	3·80	2·28
8½	8·7×8·7	48·0	*a**	BADOK	·63	·39	14·1	193	68·3	44·7	15·7	3·70	2·20
	9·1×8·8	63·3	*ai*	YOHYT	·83	·51	18·6	268	93·4	59·1	21·2	3·80	2·24
	9·4×8·9	78·8	*ar*	YOANT	1·02	·63	23·2	350	120	74·1	27·1	3·89	2·28

For nett depth of web, between fillets, see page 38.

SIZES AND PROPERTIES OF

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.



For Explanation, see page 21. For Key Drawings, see page 14.

Nominal Depth.	Dimensions.	Weight per Foot.	Delivery.	Code Word.	Flange Thickness.	Web Thickness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
	d × b				T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.			Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
	9·0 × 9·3	40·9	*a*	YOOZA	·49	·31	12·0	186	66·6	41·2	14·3	3·93	2·35
	9·4 × 9·4	51·9	*a*	BETAC	·67	·28	15·3	262	94·2	55·5	19·9	4·14	2·48
9½	9·4 × 9·4	58·7	*a*	BAEJM	·71	·43	17·2	281	100	59·4	21·1	4·03	2·40
	9·8 × 9·6	75·3	*ai*	YOIPY	·91	·55	22·1	377	132	76·5	27·5	4·13	2·44
	10·2 × 9·7	92·2	*ar*	YOARY	1·10	·67	27·1	482	167	94·2	34·5	4·22	2·49
	9·4 × 9·7	44·2	*a**	YOPAJ	·51	·31	13·0	221	78·4	46·7	16·2	4·12	2·46
	9·8 × 9·8	55·6	*a*	BETDE	·69	·29	16·4	306	110	62·1	22·2	4·32	2·59
10	9·8 × 9·8	61·1	*a**	BAELP	·71	·43	18·0	320	113	64·9	22·9	4·24	2·50
	10·3 × 10·0	82·5	*ai*	YOJIR	·94	·59	24·3	452	158	87·6	31·6	4·32	2·55
	10·8 × 10·1	103	*ar*	YOASZ	1·18	·71	30·3	596	204	110	40·4	4·43	2·60
	9·8 × 10·1	46·0	*a*	YOPBI	·51	·31	13·5	250	88·3	50·9	17·4	4·31	2·56
	10·2 × 10·2	59·5	*a*	BETJY	·71	·30	17·5	354	127	69·1	24·7	4·50	2·69
10½	10·2 × 10·2	63·6	*a*	BAEZD	·71	·43	18·7	362	127	70·7	24·8	4·40	2·60
	10·8 × 10·4	90·0	*ai*	YOJVY	·98	·63	26·5	538	187	99·8	36·0	4·51	2·65
	11·3 × 10·6	116	*ar*	YOAWD	1·26	·79	34·0	733	250	129	47·2	4·64	2·71
	10·5 × 10·9	51·4	*a*	YOPEF	·53	·32	15·1	320	115	61·0	21·0	4·61	2·76
	11·0 × 11·0	67·7	*a*	BETYJ	·75	·31	19·9	468	167	84·9	30·3	4·85	2·89
11	11·0 × 11·0	75·7	*a**	BAHEL	·79	·47	22·3	498	176	90·3	31·9	4·73	2·81
	11·6 × 11·2	105	*ai*	YOKUV	1·08	·67	31·0	732	255	126	45·5	4·86	2·87
	12·2 × 11·4	135	*ar*	YOBAH	1·38	·83	39·6	991	339	162	59·6	5·00	2·93
	11·4 × 11·7	58·9	*a**	YOPGA	·57	·34	17·3	431	152	75·8	26·0	4·99	2·96
	11·8 × 11·8	76·4	*a*	BEVEF	·79	·33	22·5	607	216	103	36·6	5·20	3·10
12	11·8 × 11·8	81·2	*a**	BAKEN	·79	·47	23·9	619	216	105	36·6	5·09	3·01
	12·5 × 12·0	120	*ai*	YOLIT	1·14	·71	35·2	967	333	155	55·5	5·24	3·07
	13·2 × 12·2	158	*ar*	YOBIK	1·50	·91	46·3	1360	459	206	74·9	5·42	3·15
	12·1 × 11·7	65·8	*a*	YOPHO	·63	·37	19·3	541	168	89·4	28·7	5·30	2·95
	12·6 × 11·8	81·4	*a*	BEVHO	·83	·35	23·9	731	227	116	38·4	5·53	3·08
12½	12·6 × 11·8	90·3	*a*	BAKIP	·87	·51	26·5	775	238	123	40·3	5·40	2·99
	13·3 × 12·0	128	*ai*	YOLSE	1·22	·71	37·5	1165	353	175	58·8	5·57	3·07
	14·0 × 12·2	166	*ar*	YOBJE	1·57	·91	48·8	1607	478	229	78·3	5·74	3·13

For nett depth of web, between fillets, see page 38.

SIZES AND PROPERTIES OF

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

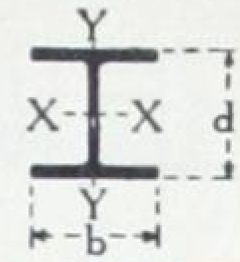
For Explanation, see page 21. For Key Drawings, see page 14.

Nominal Depth.	Dimensions. d × b	Weight per Foot.	Delivery.	Code Word.	Flange Thickness. T	Web Thickness. t	Area. A	Moments of Inertia. I_x	Moments of Inertia. I_y	Section Moduli. Z_x	Section Moduli. Z_y	Radii of Gyration. g_x	Radii of Gyration. g_y
Ins.	Ins.	Lb.			Ins.	Ins.	Ins.²	Ins.⁴	Ins.⁴	Ins.³	Ins.³	Ins.	Ins.
	13·0×11·7	70·7	*a*	YOPIN	·67	·39	20·8	663	178	102	30·5	5·65	2·93
	13·4×11·8	86·2	*a*	BEVIG	·87	·37	25·3	870	238	130	40·3	5·85	3·06
13½	13·4×11·8	91·6	*a*	BAKMA	·87	·51	26·9	888	238	133	40·3	5·74	2·97
	14·1×12·0	130	*ai*	YOMAS	1·22	·71	38·1	1329	353	189	58·8	5·91	3·04
	14·8×12·2	168	*ar*	YOBLO	1·57	·91	49·5	1826	478	247	78·3	6·07	3·11
	13·7×11·7	75·7	*a*	YOPJU	·71	·41	22·2	782	189	114	32·3	5·93	2·91
	14·2×11·8	91·3	*a*	BEVKY	·91	·39	26·8	1026	249	145	42·1	6·18	3·04
14	14·2×11·8	101	*a**	BALEP	·94	·55	29·7	1084	260	153	44·0	6·04	2·96
	14·6×11·9	123	*ai*	YOMIV	1·14	·67	36·0	1355	324	186	54·5	6·13	3·00
	15·0×12·0	145	*ai*	YOMUX	1·34	·79	42·5	1644	391	220	65·2	6·22	3·03
	15·4×12·2	170	*ar*	YOBUM	1·57	·91	50·0	2009	474	260	77·9	6·34	3·08
	14·6×11·7	80·6	*b*	YOPLY	·75	·43	23·7	940	199	129	34·1	6·29	2·90
	15·0×11·8	96·3	*b*	BEVUJ	·94	·41	28·3	1199	260	160	43·9	6·51	3·03
15	15·0×11·8	102	*b*	BALRO	·94	·55	30·1	1224	260	164	44·0	6·38	2·94
	15·4×11·9	124	*bi*	YOMWO	1·14	·67	36·6	1527	324	199	54·5	6·46	2·97
	15·7×12·0	147	*bi*	YOMZY	1·34	·79	43·1	1850	391	235	65·2	6·55	3·01
	16·2×12·2	172	*br*	YOBYN	1·57	·91	50·7	2255	474	278	77·9	6·67	3·06
	15·3×11·7	84·9	*a*	YOPOC	·79	·43	24·9	1085	210	142	35·9	6·60	2·90
	15·7×11·8	101	*a*	BEWAF	·98	·43	29·8	1390	271	176	45·8	6·83	3·01
16	15·7×11·8	110	*a*	BALUS	1·02	·55	32·3	1457	281	185	47·7	6·71	2·95
	16·1×11·9	132	*ai*	YONAT	1·22	·67	38·9	1794	346	222	58·1	6·79	2·98
	16·5×12·0	155	*ai*	YONEV	1·42	·79	45·5	2152	414	260	69·0	6·88	3·02
	16·9×12·1	172	*ar*	YOCAJ	1·57	·87	50·6	2448	469	291	77·3	6·95	3·04
	16·3×11·7	90·4	*b*	YOPPE	·83	·45	26·6	1312	220	161	37·7	7·03	2·88
	16·7×11·8	107	*b*	BEWEG	1·02	·45	31·4	1644	281	196	47·6	7·23	2·99
17	16·7×11·8	112	*b*	BALYT	1·02	·55	32·9	1670	281	200	47·7	7·13	2·93
	17·1×11·9	134	*bi*	YONOY	1·22	·67	39·5	2052	346	240	58·1	7·20	2·96
	17·5×12·0	157	*bi*	YONUZ	1·42	·79	46·3	2458	414	281	69·0	7·29	2·99
	17·8×12·1	175	*br*	YOCEK	1·57	·87	51·5	2791	469	313	77·4	7·36	3·02
	17·2×11·7	96·3	*a*	YOPUB	·87	·47	28·3	1545	231	179	39·5	7·39	2·86
	17·7×11·8	113	*a*	BEWYL	1·06	·47	33·2	1934	292	218	49·5	7·63	2·97
18	17·7×11·8	122	*a*	BAMAF	1·10	·59	35·9	2024	303	228	51·3	7·51	2·91
	18·0×11·9	140	*ai*	YONVE	1·26	·67	41·0	2360	354	262	59·5	7·58	2·93
	18·3×12·0	157	*ai*	YONYO	1·42	·75	46·2	2710	406	295	67·7	7·66	2·96
	18·7×12·0	175	*ar*	YOCIL	1·57	·83	51·5	3075	460	330	76·4	7·73	2·99

For nett depth of web, between fillets, see page 38.

SIZES AND PROPERTIES OF

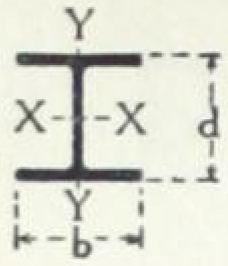
BROAD FLANGE BEAMS, GREY PROCESS.—Continued.



For Explanation, see page 21. For Key Drawings, see page 14.

Nominal Depth.	Dimensions. d × b	Weight per Foot.	Delivery.	Code Word.	Flange Thickness. T	Web Thickness. t	Area. A	Moments of Inertia. I_x	I_y	Section Moduli. Z_x	Z_y	Radii of Gyration. g_x	g_y
Ins.	Ins.	Lb.			Ins.	Ins.	$Ins.^2$	$Ins.^4$	$Ins.^4$	$Ins.^3$	$Ins.^3$	Ins.	Ins.
	18·3×11·7	102	*c*	YORAF	·91	·49	30·0	1832	241	200	41·3	7·82	2·84
	18·7×11·8	119	*c*	BEYFS	1·10	·49	34·9	2249	303	240	51·3	8·03	2·95
19	18·7×11·8	124	*c*	BAMIR	1·10	·59	36·5	2286	303	244	51·3	7·91	2·88
	19·0×11·9	141	*ci*	YOOHR	1·26	·67	41·6	2662	354	280	59·5	8·00	2·91
	19·3×12·0	160	*ci*	YOOJS	1·42	·75	47·0	3053	406	316	67·7	8·06	2·94
	19·6×12·0	178	*cr*	YOCYP	1·57	·83	52·3	3461	460	352	76·4	8·13	2·96
	19·2×11·7	108	*a*	YORBO	·94	·51	31·7	2122	252	221	43·1	8·18	2·82
	19·7×11·8	125	*a*	BEYHE	1·14	·51	36·6	2601	314	264	53·2	8·43	2·93
20	19·7×11·8	135	*a*	BAMOS	1·18	·63	39·6	2720	325	276	55·0	8·29	2·87
	20·1×11·9	158	*ai*	YOOKT	1·38	·75	46·6	3259	391	325	65·7	8·36	2·90
	20·5×12·0	180	*ar*	YODAK	1·57	·83	52·9	3798	456	371	75·9	8·47	2·93
	21·2×11·7	113	*c*	YORCE	·96	·51	33·2	2688	257	253	44·0	9·00	2·78
	21·7×11·8	132	*c*	BEYIJ	1·18	·53	38·9	3314	325	306	55·0	9·23	2·89
22	21·7×11·8	139	*c*	BAMUT	1·18	·63	40·8	3372	325	311	55·0	9·09	2·82
	22·0×11·9	163	*ci*	YOOLV	1·38	·75	48·1	4033	391	366	65·7	9·16	2·85
	22·4×12·0	185	*cr*	YODEL	1·57	·83	54·5	4688	456	418	75·9	9·27	2·89
	23·1×11·7	124	*b*	YOREJ	1·02	·55	36·5	3457	273	299	46·7	9·74	2·74
	23·6×11·8	141	*b*	BEYKO	1·22	·55	41·4	4154	336	352	56·8	10·00	2·85
24	23·6×11·8	152	*b*	BANRE	1·26	·67	44·8	4345	347	368	58·7	9·85	2·78
	23·9×11·9	171	*bi*	YOONY	1·42	·75	50·4	4961	398	414	66·9	9·92	2·81
	24·3×12·0	191	*br*	YODNO	1·57	·83	56·0	5599	451	462	75·4	9·99	2·84
	25·1×11·7	128	*b*	YORFU	1·02	·55	37·6	4152	273	331	46·7	10·52	2·70
26	25·6×11·8	157	*b*	BAORY	1·26	·67	46·1	5209	347	407	58·7	10·63	2·74
	25·9×11·9	176	*bi*	YOOPZ	1·42	·75	51·9	5940	398	458	66·9	10·70	2·77
	26·2×12·0	196	*br*	YODUP	1·57	·83	57·7	6694	452	511	75·4	10·77	2·80
	27·1×11·7	141	*b*	YORHI	1·10	·59	41·4	5249	294	388	50·3	11·26	2·67
28	27·6×11·8	171	*b*	BAOSZ	1·34	·71	50·2	6494	369	471	62·4	11·37	2·71
	28·0×11·9	201	*br*	YOECK	1·57	·83	59·1	7788	447	556	75·0	11·48	2·75
	29·1×11·7	145	*b*	YORIL	1·10	·59	42·6	6153	294	424	50·3	12·02	2·63
30	29·5×11·8	176	*b*	BAVZE	1·34	·71	51·6	7598	369	515	62·4	12·13	2·67
	30·0×11·9	207	*br*	YOEGN	1·57	·83	60·7	9100	447	607	75·0	12·24	2·71

For nett depth of web, between fillets, see page 39.



SIZES AND PROPERTIES OF

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

For Key Drawings, see page 14.

Nominal Depth.	Dimensions.	Weight per Foot.	Delivery.	Code Word.	Flange Thick-ness.	Web Thick-ness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
	d × b				T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.			Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
	31·2×11·7	159	*b*	YORKA	1·18	·63	46·8	7682	319	493	54·3	12·81	2·61
32	31·5×11·8	180	*b*	BAWIC	1·34	·71	53·0	8802	369	559	62·4	12·89	2·64
	32·0×11·9	212	*br*	YOELS	1·57	·83	62·4	10529	447	659	75·0	12·99	2·68
	33·1×11·7	174	*c*	YOROD	1·26	·67	51·3	9384	340	567	58·0	13·54	2·57
34	33·5×11·8	196	*c*	BAWOD	1·42	·75	57·5	10665	391	637	66·1	13·61	2·61
	33·8×11·9	218	*cr*	YOEMT	1·57	·83	64·0	11942	443	707	74·5	13·66	2·63
	35·1×11·7	179	*c*	YORPY	1·26	·67	52·6	10706	340	610	58·0	14·28	2·54
36	35·4×11·8	201	*c*	BAWUF	1·42	·75	58·9	12158	391	686	66·2	14·35	2·57
	35·7×11·9	223	*cr*	YOENV	1·57	·83	65·6	13606	443	761	74·6	14·40	2·60
	37·1×11·7	183	*c*	YORUJ	1·26	·67	53·9	12141	340	655	58·0	15·01	2·51
38	37·4×11·8	206	*c*	BAWZA	1·42	·75	60·4	13765	391	736	66·2	15·08	2·54
	37·7×11·9	229	*cr*	YOERZ	1·57	·83	67·2	15395	443	816	74·6	15·13	2·57
	39·1×11·7	188	*b*	YOSAN	1·26	·67	55·2	13670	340	700	58·0	15·74	2·48
40	39·4×11·8	211	*b*	BAYEC	1·42	·75	61·9	15490	391	787	66·2	15·81	2·51
	39·7×11·9	234	*br*	YOEVD	1·57	·83	68·8	17315	443	873	74·6	15·86	2·54

SPECIAL SIZES OF B.F. BEAMS, GREY PROCESS, WITH EXTRA WIDE FLANGES.

Nominal Depth.	Dimensions.	Weight per Foot.	Code Word.	Flange Thick-ness.	Web Thick-ness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
	d × b			T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.		Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
4	3·7×5·1	13·6	YUDOS	·31	·20	4·0	10·1	7·0	5·4	2·75	1·59	1·33
5	4·5×5·9	15·8	YUDPA	·31	·20	4·6	17·7	10·8	7·9	3·66	1·95	1·53
5½	5·2×6·7	19·3	YUDUT	·33	·22	5·7	29·6	16·7	11·3	5·00	2·29	1·72
6	5·6×7·1	20·4	YUDVY	·33	·22	6·0	36·6	19·9	13·0	5·60	2·47	1·82
6¼	5·9×7·5	23·1	YUEGS	·35	·24	6·8	45·3	24·7	15·3	6·61	2·58	1·91
7	6·8×7·9	27·2	YUEMZ	·39	·26	8·0	69·9	32·1	20·6	8·14	2·96	2·00
8	7·5×8·7	32·8	YUERF	·43	·28	9·6	103	46·9	27·5	10·8	3·27	2·21

These special sections with extra wide flanges can be supplied, from rolls, as readily as the standard sections if ordered in quantities of at least 250 feet of a size.

For safe loads when used as Stanchions see page 92; as Poles, page 154.

SIZES AND PROPERTIES OF

BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

Notes to the Table on pages 16–20.

WEIGHT PER FOOT. As explained on page 11, the various sections are rolled in four standard weights—known as the Die, Dil, Din and Dir weights—and can also be rolled to intermediate weights, of which some typical examples (marked *i*) are included in the table.

(i) The first line in each group is the Die or minimum weight ; for most purposes the minimum weights are to be preferred.

(ii) The second line in each group (up to 24″ × 12″) is the Dil section. This is similar to the former standard weight (Din series) but has a reduced web.

(iii) The weight directly opposite the nominal size is the Din or medium weight (formerly the standard weight).

(iv) The last line in each group is the Dir or maximum weight.

(v) Weights marked *i* in the " Delivery " column are typical intermediate weights.

DELIVERY. The various weights of each section are produced by merely varying the spacing of the rolls. Accordingly, all the weights can be obtained (from rolls) equally readily ; and in any desired quantity, except as mentioned below.

(i) The Dir series (maximum weights), marked " *r* " in the " Delivery " column, can only be supplied in lots ranging from 3 to 9 tons minimum, according to section (see table on page 286).

(ii) Intermediate weights, including the typical examples marked " *i* " in the tables, can only be supplied in lots ranging from 18 to 36 tons minimum according to section (see table on page 286).

The other symbols in the " Delivery " column have the following meanings :—

*	Normally stocked in the U.K. (but see page 6).
a	Average rolling dates 3 to 4 weeks.
b	,, ,, ,, 4 to 6 ,,
c	,, ,, ,, 6 to 8 ,,

ECONOMY. The Die or minimum weights are the most economical ; i.e. shew the highest ratio of capacity to weight, both as beams and as columns.

SECTIONS WITH EXTRA WIDE FLANGES. As columns, the special sections listed on page 20 are even more economical than the standard sections, and are as readily obtainable if ordered in fair quantities.

BROAD FLANGE BEAMS, GREY PROCESS.

SPECIAL AMERICAN SIZES.

For Explanation, see below. For Key Drawing, see page 14.

Nominal Size.	Exact Size.	Weight per Foot.	Code Word.	Thickness.		Area.	Moments of Inertia.		Section Modulus.	Radius of Gyration
d × b	d × b			Flange.	Web.	A	I_x	I_y	Z_x	g_y
Ins.	Ins.	Lb.		Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.
	6·0 × 6·0	20		·37	·25	5·89	39·2	13·5	13·1	1·51
	6·1 × 6·0	23		·43	·27	6·76	46·3	15·9	15·1	1·53
6 × 6	6·2 × 6·1	27	YUMAY	·50	·33	7·92	55·0	18·8	17·6	1·54
	6·4 × 6·1	30		·56	·35	8·81	63·2	21·4	19·8	1·56
	6·7 × 6·2	41		·75	·49	12·0	91·2	30·5	27·0	1·59
	8·0 × 8·0	31		·43	·29	9·12	110	37·0	27·4	2·01
	8·1 × 8·0	35		·49	·31	10·3	126	42·5	31·1	2·03
8 × 8	8·2 × 8·1	40	YUMCO	·56	·36	11·8	146	49·0	35·5	2·04
	8·5 × 8·1	48		·68	·40	14·1	184	60·9	43·2	2·08
	9·0 × 8·3	67		·93	·57	19·7	272	88·6	60·4	2·12
	10·0 × 10·0	49		·56	·34	14·4	273	93·0	54·6	2·54
	10·1 × 10·0	54		·62	·37	15·9	306	104	60·4	2·56
	10·2 × 10·1	60		·68	·41	17·7	344	116	67·1	2·57
10 × 10	10·5 × 10·2	72	YUMEZ	·81	·51	21·2	421	142	80·1	2·59
	10·9 × 10·3	89		1·00	·61	26·2	542	181	99·7	2·63
	11·1 × 10·3	100		1·12	·68	29·4	625	207	112	2·65
	11·4 × 10·4	112		1·25	·75	32·9	719	235	126	2·67
	12·1 × 12·0	65		·61	·39	19·1	533	175	88·0	3·02
	12·5 × 12·1	85		·80	·49	25·0	723	235	116	3·07
12 × 12	12·7 × 12·2	99	YUMIB	·92	·58	29·1	859	278	135	3·09
	13·1 × 12·3	120		1·11	·71	35·3	1072	345	163	3·13
	13·6 × 12·4	147		1·36	·84	43·2	1374	437	202	3·18
	14·1 × 12·6	176		1·61	1·00	51·8	1713	538	243	3·22
14 × 12	14·1 × 12·0	78	YUMOC	·72	·43	22·9	851	207	121	3· 0

The sizes listed above, except the 14" section, can be supplied from Differdange in the following minimum quantities only :—

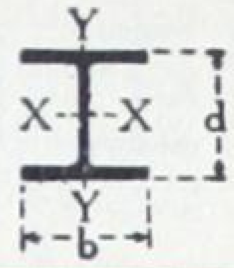
(a) The 6", 10", and 12" sizes in lots of at least 25 tons of any one size and weight.
(b) The 8" in lots of at least 250 tons, comprising not less than 25 tons of any one weight.

Subject to these reservations, specifications can normally be rolled within 2 to 4 weeks from receipt of order.

It will be noticed that the tabulated code words indicate the sizes only ; and must accordingly be followed by the weight per foot (e.g. YUMCO 40). In cabled orders or enquiries, the message should be so worded as to show the required quantity of each individual weight.

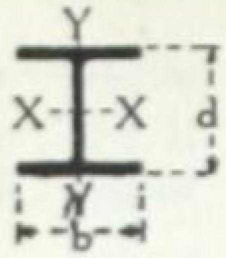
BROAD FLANGE BEAMS, GREY PROCESS.

METRIC UNITS.



Nominal Depth.	Exact Size and Weight per Metre.		Delivery.	Code Word.	Flange Thickness.	Web Thickness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.		Nominal Depth.
d	d × b	Wt.			T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y	d
Ins.	Mm.	Kilos.			Mm.	Mm.	$Cm.^2$	$Cm.^4$	$Cm.^4$	$Cm.^3$	$Cm.^3$	Cm.	Cm.	Ins.
	94× 99	16,3	*a*	YOOPO	8	5	20,8	327	130	70	26	3,97	2,50	
	100×100	21,1	*a*	BEAHL	11	5	26,9	472	184	94	37	4,18	2,61	
4	100×100	22,1	*a*	BAABA	11	6,5	28,1	478	184	96	37	4,12	2,56	4
	112×104	34,6	*ar*	YOACH	17	10	44,0	856	315	153	61	4,41	2,68	
	114×119	19,6	*a*	YOOPT	8	5	25,0	598	225	105	38	4,89	3,00	
	120×120	25,4	*a*	BEANY	11	5	32,3	849	317	142	53	5,12	3,13	
5	120×120	26,5	*a*	BAANG	11	6,5	33,8	860	317	143	53	5,04	3,06	5
	132×123	41,5	*ar*	YOADS	17	10	52,8	1499	535	227	87	5,33	3,18	
	133×138	24,4	*a*	YOORY	8,5	5,5	31,1	1020	373	153	54	5,72	3,46	
	140×140	31,4	*a*	BEBMO	12	4,5	40,1	1477	549	211	78	6,07	3,70	
5½	140×140	34,6	*a**	BABAD	12	8,0	44,1	1522	550	217	79	5,87	3,53	5½
	164×148	71,3	*ar*	YOAGM	24	16	90,8	3761	1302	459	176	6,43	3,79	
	143×148	26,2	*a**	YOOSH	8,5	5,5	33,3	1277	460	179	62	6,18	3,71	
	150×150	33,9	*a*	BEBYP	12	4,75	43,2	1843	676	246	90	6,53	3,95	
6	150×150	37,2	*a**	BABEF	12	8,0	47,3	1897	676	253	90	6,33	3,78	6
	174×158	76,3	*ar*	YOAGT	24	16	97,2	4614	1583	530	200	6,89	4,04	
	150×157	29,7	*a*	YOOTU	9,0	6,0	37,9	1588	584	212	75	6,47	3,92	
	160×160	39,2	*a*	BECAK	13	5,0	50,0	2420	888	302	111	6,96	4,21	
6¼	160×160	45,8	*a*	BABHO	14	9,0	58,4	2634	958	329	120	6,72	4,05	6¼
	182×167	83,4	*ar*	YOAHN	25	16	106,3	5562	1947	611	233	7,23	4,28	
	172×177	36,9	*a**	YOOVI	10	6,5	147,0	2605	925	303	104	7,45	4,43	
	180×180	47,4	*a*	BEDEM	14	5,5	60,4	3730	1362	414	151	7,86	4,75	
7	180×180	51,6	*a**	BACGE	14	9,0	65,8	3833	1363	426	151	7,63	4,55	7
	202×187	93,8	*ar*	YOAJP	25	16	.19,5	7929	2732	785	292	8,15	4,78	
	190×197	44,7	*a**	YOOWO	11	7,0	57,0	3879	1403	408	143	8,24	4,96	
	200×200	56,6	*a*	BEIZK	15	6,0	72,1	5519	2002	552	200	8,75	5,27	
8	200×200	64,9	*a**	BACYL	16	10	82,7	5952	2136	595	214	8,48	5,08	8
	220×206	106,7	*ar*	YOAMS	26	16	135,9	10897	3796	991	369	8,96	5,28	
	211×217	51,4	*a*	YOOXS	11,5	7,25	65,5	5532	1960	524	181	9,19	5,47	
	220×220	66,4	*a*	BERBE	16	6,5	84,5	7859	2842	714	258	9,64	5,80	
8½	220×220	71,5	*a**	BADOK	16	10	91,1	8052	2843	732	258	9,40	5,59	8½
	240×226	117,4	*ar*	YOANT	26	16	149,5	14565	5011	1214	443	9,88	5,79	
	229×237	60,9	*a*	YOOZA	12,5	7,75	77,5	7739	2776	676	234	9,99	5,98	
	240×240	77,3	*a*	BETAC	17	7,0	98,5	10917	3919	910	327	10,52	6,31	
9½	240×240	87,4	*a*	BAEJM	18	11	111,3	11686	4152	974	346	10,25	6,11	9½
	260×246	137,3	*ar*	YOARY	28	17	174,9	20069	6959	1544	566	10,71	6,32	

For explanations, see page 21.



BROAD FLANGE BEAMS, GREY PROCESS.

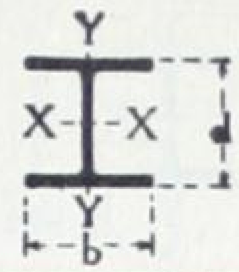
METRIC UNITS.—Continued.

Nominal Depth.	Exact Size and Weight per Metre.		Delivery.	Code Word.	Flange Thickness.	Web Thickness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.		Nominal Depth.
d	d × b	Wt.			T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y	d
Ins.	Mm.	Kilos.			Mm.	Mm.	Cm.^{2}	Cm.^{4}	Cm.^{4}	Cm.^{3}	Cm.^{3}	Cm.	Cm.	Ins.
	240 × 247	65,8	a*	YOPAJ	13	8,0	83,8	9199	3268	766	265	10,47	6,24	
	250 × 250	82,9	a	BETDE	17,5	7,25	105,6	12714	4559	1017	365	10,97	6,57	
10	250 × 250	91,1	a*	BAELP	18	11	116,0	13298	4692	1064	375	10,71	6,36	10
	274 × 257	153,2	ar	YOASZ	30	18	195,2	24800	8502	1810	662	11,27	6,60	
	250 × 257	68,5	a	YOPBI	13	8,0	87,2	10430	3680	834	286	10,94	6,49	
	260 × 260	88,6	a	BETJY	18	7,5	112,9	14722	5275	1132	406	11,42	6,84	
10½	260 × 260	94,8	a	BAEZD	18	11	120,7	15050	5278	1158	406	11,17	6,61	10½
	288 × 269	172,3	ar	YOAWD	32	20	219,4	30517	10401	2119	773	11,81	6,89	
	267 × 277	76,4	a	YOPEF	13,5	8,25	97,4	13352	4785	1000	345	11,71	7,01	
	280 × 280	100,9	a	BETYJ	19	8,0	128,5	19476	6954	1391	497	12,31	7,35	
11	280 × 280	112,7	a*	BAHEL	20	12	143,6	20722	7324	1480	523	12,01	7,14	11
	310 × 289	200,5	ar	YOBAH	35	21	255,5	41248	14105	2661	976	12,71	7,44	
	289 × 297	87,6	a*	YOPGA	14,5	8,75	111,7	17964	6335	1243	426	12,68	7,53	
	300 × 300	113,7	a	BEVEF	20	8,5	144,9	25247	9003	1683	600	13,20	7,88	
12	300 × 300	120,9	a*	BAKEN	20	12	154,0	25759	9007	1717	600	12,93	7,65	12
	336 × 311	234,7	ar	YOBIK	38	23	298,9	56576	19084	3368	1227	13,76	7,99	
	308 × 297	97,9	a	YOPHO	16	9,5	124,7	22558	6992	1465	471	13,45	7,49	
	320 × 300	121,2	a	BEVHO	21	9,0	154,4	30439	9454	1902	630	14,04	7,82	
12½	320 × 300	134,5	a	BAKIP	22	13	171,3	32249	9910	2016	661	13,72	7,61	12½
	356 × 310	247,2	ar	YOBJE	40	23	314,9	66878	19897	3757	1284	14,57	7,95	
	330 × 297	105,2	a	YOPIN	17	10	134,0	27621	7429	1674	500	14,35	7,44	
	340 × 300	128,4	a	BEVIG	22	9,5	163,6	36185	9904	2129	660	14,87	7,78	
13½	340 × 300	136,5	a	BAKMA	22	13	173,9	36942	9910	2173	661	14,57	7,55	13½
	376 × 310	250,8	ar	YOBLO	40	23	319,5	76003	19900	4043	1284	15,45	7,90	
	348 × 297	112,6	a	YOPJU	18	10,5	143,5	32564	7867	1871	530	15,06	7,40	
	360 × 300	135,9	a	BEVKY	23	10	173,2	42694	10355	2372	690	15,70	7,73	
14	360 × 300	150,3	a*	BALEP	24	14	191,5	45122	10813	2507	721	15,35	7,51	14
	392 × 309	253,4	ar	YOBUM	40	23	322,7	83591	19710	4265	1276	16,09	7,82	
	370 × 297	120,0	b	YOPLY	19	11	153,2	39137	8304	2116	559	15,98	7,36	
	380 × 300	143,4	b	BEVUJ	24	10,5	182,6	49880	10807	2625	720	16,53	7,69	
15	380 × 300	152,5	b	BALRO	24	14	194,3	50949	10813	2682	721	16,19	7,46	15
	412 × 309	257,0	br	YOBYN	40	23	327,3	93850	19712	4556	1276	16,93	7,76	

For explanations, see page 21.

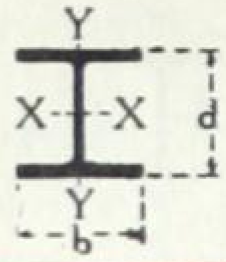
BROAD FLANGE BEAMS, GREY PROCESS.

METRIC UNITS.—Continued.



Nominal Depth.	Exact Size and Weight per Metre.		Delivery.	Code Word.	Flange Thickness.	Web Thickness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.		Nominal Depth.
d	d × b	Wt.			T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y	d
Ins.	Mm.	Kilos.			Mm.	Mm.	Cm.²	Cm.⁴	Cm.⁴	Cm.³	Cm.³	Cm.	Cm.	Ins.
	388 × 297	126,3	*a*	YOPOC	20	11	160,9	45208	8741	2330	589	16,77	7,37	
	400 × 300	150,9	*a*	BEWAF	25	11	192,3	57835	11258	2892	751	17,34	7,65	
16	400 × 300	163,7	*a*	BALUS	26	14	208,5	60642	11714	3032	781	17,05	7,50	**16**
	428 × 308	256,5	*ar*	YOCAJ	40	22	326,7	101876	19518	4761	1267	17,65	7,72	
	415 × 297	134,6	*b*	YOPPE	21	11,5	171,4	54684	9179	2635	618	17,86	7,32	
	425 × 300	159,1	*b*	BEWEG	26	11,5	202,7	68400	11709	3219	781	18,37	7,60	
17	425 × 300	166,4	*b*	BALYT	26	14	212,0	69483	11714	3270	781	18,10	7,43	**17**
	453 × 308	260,8	*br*	YOCEK	40	22	332,2	116165	19521	5129	1268	18,70	7,67	
	438 × 297	143,3	*a*	YOPUB	22	12	182,5	64379	9618	2940	648	18,77	7,26	
	450 × 300	168,0	*a*	BEWYL	27	12	214,1	80468	12161	3576	811	19,39	7,54	
18	450 × 300	181,8	*a*	BAMAP	28	15	231,6	84223	12619	3743	841	19,07	7,38	**18**
	474 × 306	260,7	*ar*	YOCIL	40	21	332,1	127975	19144	5400	1251	19,63	7,59	
	465 × 297	151,9	*c*	YORAF	23	12,5	193,5	76350	10056	3284	677	19,86	7,21	
	475 × 300	176,6	*c*	BEYFS	28	12,5	224,9	93584	12611	3940	841	20,39	7,49	
19	475 × 300	184,8	*c*	BAMIR	28	15	235,4	95122	12620	4005	841	20,10	7,32	**19**
	499 × 306	264,8	*cr*	YOCYP	40	21	337,3	144037	19146	5773	1251	20,67	7,53	
	488 × 297	160,7	*a*	YORBO	24	13	204,7	88312	10495	3619	707	20,77	7,16	
	500 × 300	185,6	*a*	BEYHE	29	13	236,4	108257	13065	4330	871	21,40	7,43	
20	500 × 300	200,4	*a*	BAMOS	30	16	255,3	113177	13525	4527	902	21,05	7,28	**20**
	520 × 305	268,0	*ar*	YODAK	40	21	341,3	158055	18961	6079	1243	21,52	7,45	
	539 × 297	168,1	*c*	YORCE	24,5	13	214,2	111981	10715	4155	722	22,86	7,07	
	550 × 300	197,1	*c*	BEYIJ	30	13,5	251,1	137894	13517	5014	901	23,45	7,34	
22	550 × 300	206,7	*c*	BAMUT	30	16	263,3	140342	13527	5103	902	23,09	7,17	**22**
	570 × 305	276,2	*cr*	YODEL	40	21	351,8	195098	18965	6846	1244	23,55	7,34	
	588 × 297	184,7	*b*	YOREJ	26	14	235,3	144026	11375	4899	766	24,74	6,95	
	600 × 300	209,7	*b*	BEYKO	31	14	267,1	172874	13972	5762	931	25,44	7,23	
24	600 × 300	226,8	*b*	BANRE	32	17	288,9	180829	14435	6028	962	25,02	7,07	**24**
	616 × 304	283,8	*br*	YODNO	40	21	361,6	232980	18785	7564	1236	25,38	7,21	
	638 × 297	190,2	*b*	YORFU	26	14	242,3	173014	11376	5424	766	26,72	6,85	
26	650 × 300	233,5	*b*	BAORY	32	17	297,4	216783	14437	6670	962	27,00	6,97	
	666 × 304	292,1	*br*	YODUP	40	21	372,1	278583	18790	8366	1236	27,36	7,10	**26**

For explanations, see page 21.



BROAD FLANGE BEAMS, GREY PROCESS.

METRIC UNITS.—Continued.

Nominal Depth.	Exact Size and Weight per Metre.		Delivery.	Code Word.	Flange Thickness.	Web Thickness.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.		Nominal Depth.
d	d × b	Wt.			T	t	A	I_x	I_y	Z_x	Z_y	g_x	g_y	d
Ins.	Mm.	Kilos.			Mm.	Mm.	Cm.²	Cm.⁴	Cm.⁴	Cm.³	Cm.³	Cm.	Cm.	Ins.
	688 × 297	209,9	*b*	YORHI	28	15	267,4	218728	12252	6358	825	28,60	6,77	
28	700 × 300	254,4	*b*	BAOSZ	34	18	324,0	270290	15346	7723	1023	28,88	6,88	28
	712 × 303	299,4	*br*	YOECK	40	21	381,4	324175	18611	9106	1228	29,14	6,98	
	738 × 297	215,8	*b*	YORIL	28	15	274,9	256394	12254	6948	825	30,54	6,67	
30	750 × 300	261,4	*b*	BAVZE	34	18	333,0	316256	15349	8434	1023	30,82	6,79	30
	762 × 303	307,6	*br*	YOEGN	40	21	391,9	378759	18615	9941	1229	31,07	6,90	
	792 × 298	237,2	*b*	YORKA	30	16	302,2	320104	13271	8083	890	32,54	6,63	
32	800 × 300	268,5	*b*	BAWIC	34	18	342,0	366386	15351	9160	1023	32,73	6,70	32
	812 × 303	315,9	*br*	YOELS	40	21	402,4	438242	18618	10794	1229	32,98	6,80	
	842 × 298	259,6	*c*	YOROD	32	17	330,7	391019	14166	9288	951	34,38	6,54	
34	850 × 300	291,7	*c*	BAWOD	36	19	371,6	443890	16267	10444	1084	34,56	6,62	34
	858 × 302	324,0	*cr*	YOEMT	40	21	412,7	498179	18445	11613	1222	34,72	6,70	
	892 × 298	266,3	*c*	YORPY	32	17	339,2	446066	14168	10001	951	36,26	6,46	
36	900 × 300	299,1	*c*	BAWUF	36	19	381,1	506040	16270	11245	1085	36,44	6,53	36
	908 × 302	332,2	*cr*	YOENV	40	21	423,2	567556	18449	12501	1222	36,62	6,60	
	942 × 298	273,0	*c*	YORUJ	32	17	347,7	505354	14170	10729	951	38,13	6,38	
38	950 × 300	306,6	*c*	BAWZA	36	19	390,6	572953	16273	12062	1085	38,30	6,46	38
	958 × 302	340,5	*cr*	YOERZ	40	21	433,7	642220	18453	13408	1222	38,48	6,52	
	992 × 298	279,6	*b*	YOSAN	32	17	356,2	568988	14172	11472	951	39,97	6,31	
40	1000 × 300	314,0	*b*	BAYEC	36	19	400,1	644748	16276	12895	1085	40,15	6,38	40
	1008 × 302	348,7	*br*	YOEVD	40	21	444,2	722326	18456	14332	1222	40,32	6,45	

EXPLANATION. For explanation of the delivery symbols, etc., see page 21.

EXTRA WIDE FLANGES. Details of a series of Broad Flange Beams with extra wide flanges will be found on page 20.

BRITISH UNITS. For dimensions and properties in British units, see pages 16 to 20.

WEIGHTS

OF BROAD FLANGE BEAMS, GREY PROCESS.

The weights tabulated are the net calculated weights; for rolling margins, see page 268.

Nominal Depth.	DIE Series.				DIL Series.				DIN Series.				DIR Series.			
	Weight of			Feet per Ton.	Weight of			Feet per Ton.	Weight of			Feet per Ton.	Weight of			Feet per Ton.
	1 in.	1 ft.	10 ft.		1 in.	1 ft.	10 ft.		1 in.	1 ft.	10 ft.		1 in.	1 ft.	10 ft.	
Ins.	Lb.	Lb.	Tons.		Lb.	Lb.	Tons.		Lb.	Lb.	Tons.		Lb.	Lb.	Tons.	
4	·91	11·0	·049	204·6	1·2	14·2	·063	158·0	1·2	14·8	·066	150·8	1·9	23·2	·104	96·3
5	1·1	13·2	·059	170·0	1·4	17·1	·076	131·3	1·5	17·8	·080	125·6	2·3	27·9	·124	80·4
5½	1·4	16·4	·073	136·7	1·8	21·1	·094	106·0	1·9	23·3	·104	96·3	4·0	47·9	·214	46·7
6	1·5	17·6	·078	127·4	1·9	22·8	·102	98·2	2·1	25·0	·111	89·7	4·3	51·3	·229	43·7
6½	1·7	20·0	·089	112·2	2·2	26·4	·118	84·9	2·5	30·8	·137	72·8	4·7	56·1	·250	40·0
7	2·1	24·8	·111	90·4	2·7	31·9	·142	70·2	2·9	34·7	·155	64·6	5·3	63·0	·281	35·5
8	2·5	30·1	·134	74·5	3·2	38·0	·170	58·9	3·6	43·6	·195	51·3	6·0	71·7	·320	31·2
8½	2·9	34·5	·154	64·9	3·7	44·6	·199	50·2	4·0	48·1	·215	46·6	6·6	78·9	·352	28·4
9½	3·4	40·9	·183	54·8	4·3	52·0	·232	43·1	4·9	58·7	·262	38·1	7·7	92·3	·412	24·3
10	3·7	44·2	·197	50·7	4·6	55·7	·249	40·2	5·1	61·2	·273	36·6	8·6	103·0	·460	21·8
10½	3·8	46·0	·205	48·7	5·0	59·5	·266	37·6	5·3	63·7	·284	35·2	9·6	115·8	·517	19·4
11	4·3	51·4	·229	43·6	5·6	67·8	·303	33·0	6·3	75·7	·338	29·6	11·2	134·8	·602	16·6
12	4·9	58·9	·263	38·0	6·4	76·4	·341	29·3	6·8	81·2	·363	27·6	13·1	157·7	·704	14·2
12½	5·5	65·8	·294	34·1	6·8	81·5	·364	27·5	7·5	90·4	·403	24·8	13·8	166·1	·742	13·5
13½	5·9	70·7	·316	31·7	7·2	86·3	·385	26·0	7·6	91·7	·410	24·4	14·0	168·6	·752	13·3
14	6·3	75·7	·338	29·6	7·6	91·4	·408	24·5	8·4	101·0	·451	22·2	14·2	170·3	·760	13·2
15	6·7	80·7	·360	27·8	8·0	96·4	·430	23·2	8·5	102·5	·457	21·9	14·4	172·7	·771	13·0
16	7·1	84·9	·379	26·4	8·5	101·4	·453	22·1	9·2	110·0	·491	20·4	14·4	172·4	·770	13·0
17	7·5	90·4	·404	24·8	8·9	106·9	·477	21·0	9·3	111·8	·499	20·0	14·6	175·3	·782	12·8
18	8·0	96·3	·430	23·3	9·4	112·9	·504	19·8	10·2	122·2	·546	18·3	14·6	175·2	·782	12·8
19	8·5	102·1	·456	21·9	9·9	118·6	·530	18·9	10·3	124·2	·554	18·0	14·8	178·0	·794	12·6
20	9·0	108·0	·482	20·7	10·4	124·7	·557	18·0	11·2	134·7	·601	16·6	15·0	180·1	·804	12·4
22	9·4	113·0	·504	19·8	11·0	132·5	·591	16·9	11·6	138·9	·620	16·1	15·5	185·6	·828	12·1
24	10·3	124·1	·554	18·1	11·7	140·9	·629	15·9	12·7	152·4	·680	14·7	15·9	190·7	·851	11·7
26	10·7	127·8	·571	17·5	...	...	...	...	13·1	156·9	·700	14·3	16·4	196·3	·876	11·4
28	11·8	141·0	·630	15·9	...	...	...	...	14·2	170·9	·763	13·1	16·8	201·2	·898	11·1
30	12·1	145·0	·647	15·4	...	...	...	...	14·6	175·7	·784	12·8	17·2	206·7	·923	10·8
32	13·3	159·4	·712	14·1	...	...	...	...	15·0	180·4	·805	12·4	17·7	212·3	·948	10·6
34	14·5	174·5	·779	12·8	...	...	...	...	16·3	196·0	·875	11·4	18·1	217·7	·972	10·3
36	14·9	178·9	·799	12·5	...	...	...	...	16·8	201·0	·897	11·1	18·6	223·3	·997	10·0
38	15·3	183·4	·819	12·2	...	...	...	...	17·2	206·0	·920	10·9	19·1	228·8	1·02	9·8
40	15·7	187·9	·839	11·9	...	...	...	...	17·6	211·0	·942	10·6	19·5	234·3	1·04	9·6

BROAD FLANGE BEAMS AS GIRDERS

PRINTED ELSEWHERE

N.B.—For Safe Loads, etc., of R.S. Joists and Channels, see separate chapter, pages 171, 181.

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.

For Explanation, see page 36.

Nominal Size. d × b	Weight per Foot.	Delivery.	Maximum Distributed Load.	Moment of Resistance.	6 ft. Safe Load.	6 ft. Defl'n.	7 ft. Safe Load.	7 ft. Defl'n.	8 ft. Safe Load.	8 ft. Defl'n.	9 ft. Safe Load.	9 ft. Defl'n.	10 ft. Safe Load.	10 ft. Defl'n.	12 ft. Safe Load.	12 ft. Defl'n.
Ins.	Lb.		Tons.	In-Tns.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.
	11·0	a	5·9	34·0	3·8	·18	3·2	·24	2·8	·32	2·5	·40	2·3	·50	1·9	·72
	14·2	a	6·3	46·1	5·1	·17	4·4	·23	3·8	·30	3·4	·38	3·1	·47	2·6	·67
4 × 4	14·8	a	8·2	46·6	5·2	·17	4·4	·23	3·9	·30	3·5	·38	3·1	·47	2·6	·67
	23·2	ar	13·8	74·6	8·3	·15	7·1	·21	6·2	·27	5·5	·34	5·0	·42	4·1	·60
	13·2	a	7·2	51·2	5·7	·15	4·9	·20	4·3	·26	3·8	·33	3·4	·41	2·8	·59
	17·0	a	7·5	69·6	7·7	·14	6·6	·19	5·8	·25	5·2	·32	4·6	·39	3·9	·56
5 × 5	17·8	a	9·8	69·6	7·7	·14	6·6	·19	5·8	·25	5·2	·32	4·6	·39	3·9	·56
	27·9	ar	16·2	111	12	·13	11	·17	9·3	·23	8·2	·29	7·4	·36	6·2	·51
	16·4	a	9·2	74·6	8·3	·13	7·1	·17	6·2	·23	5·5	·29	5·0	·36	4·1	·51
	21·1	a	7·9	103	...	...	...	...	...	...	7·6	·27	6·9	·33	5·7	·48
5½ × 5½	23·4	a*	13·7	106	12	·12	10	·16	8·8	·21	7·8	·27	7·0	·33	5·9	·48
	47·9	ar	32·6	224	25	·10	21	·16	19	·18	17	·23	15	·29	12	·41
	17·6	a*	9·9	87·2	9·7	·12	8·3	·16	7·3	·21	6·5	·27	5·8	·33	4·8	·47
	22·8	a	9·0	120	...	...	...	...	...	...	8·9	·25	8·0	·31	6·7	·45
6 × 6	24·9	a*	14·7	123	14	·11	12	·15	10	·20	9·1	·25	8·2	·31	6·8	·45
	51·3	ar	34·5	258	29	·10	25	·13	22	·17	19	·22	17	·27	14	·39
	20·0	a	11·3	103	11	·11	9·8	·15	8·6	·20	7·6	·25	6·9	·31	5·7	·45
	26·3	a	10·1	147	...	...	...	...	...	...	...	...	9·8	·29	8·2	·42
6½ × 6½	30·8	a	17·6	161	...	...	15	·14	13	·19	12	·24	11	·29	8·9	·42
	56·0	ar	36·1	298	33	·09	28	·13	25	·16	22	·21	20	·26	17	·37
	24·8	a*	14·1	148	...	...	...	...	12	·17	...	...	9·9	·27	8·2	·39
	31·9	a	12·5	202	...	...	...	...	...	...	...	...	...	...	11	·37
7 × 7	34·7	a*	19·9	208	...	...	20	·13	17	·17	15	·21	14	·26	12	·37
	63·0	ar	40·1	383	...	...	36	·11	32	·15	28	·19	26	·23	21	·33
	30·1	a*	16·8	199	...	...	...	...	17	·16	...	...	13	·25	11	·35
	38·0	a	15·1	269	...	...	...	...	...	...	...	...	...	...	15	·34
8 × 8	43·6	a*	24·6	280	...	...	...	...	24	·15	22	·19	19	·23	16	·34
	71·6	ar	43·6	484	...	...	...	...	40	·14	36	·17	32	·21	27	·31
	34·5	a	19·3	256	...	...	...	...	...	...	...	...	17	·22	14	·32
	44·6	a	18·0	349	...	...	...	...	...	...	...	...	...	...	...	...
8½ × 8½	48·0	a*	27·0	358	...	...	...	...	...	...	...	...	24	·21	20	·31
	78·8	ar	47·6	593	...	...	...	...	...	...	...	...	40	·20	33	·28
	40·9	a	22·3	330	...	...	...	...	...	...	...	...	22	·21	18	·30
	51·9	a	21·2	444	...	...	...	...	...	...	...	...	...	...	...	...
9½ × 9½	58·7	a	32·5	475	...	...	...	...	...	...	...	...	32	·20	26	·28
	92·2	ar	54·9	754	...	...	...	...	...	...	...	...	50	·18	42	·26

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS : 8 TONS STRESS.

14 ft.		16 ft.		18 ft.		20 ft.		22 ft.		24 ft.		26 ft.		28 ft.		30 ft.		Nominal Depth.
Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	
Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Ins.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4
2·0	·92	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
2·4	·80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
3·3	·77	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
3·3	·77	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5
5·3	·70	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
3·6	·70	3·1	·91	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
4·9	·65	4·3	·86	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
5·0	·65	4·4	·86	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5½
11	·56	9·3	·73	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
4·2	·65	3·6	·84	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
5·7	·61	5·0	·80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
5·9	·61	5·1	·80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6
12	·53	11	·69	9·6	·87	8·6	1·1	...	...	...	...	...	...	...	...	...	...	
4·9	·61	4·3	·80	3·8	1·0	...	...	...	...	...	...	...	...	...	...	...	...	
7·0	·57	6·1	·75	5·5	·95	...	...	...	...	...	...	...	...	...	...	...	...	
7·7	·57	6 7	·75	6·0	·95	...	...	...	...	...	...	...	...	...	...	...	...	6½
14	·50	12	·66	11	·83	9·9	1·0	...	...	...	...	...	...	...	...	...	...	
7·1	·53	6·2	·70	5·5	·88	4·9	1·1	...	...	...	...	...	...	...	...	...	...	
9·6	·51	8·4	·67	7·5	·84	6·7	1·0	...	...	...	...	...	...	...	...	...	...	
9·9	·51	8·7	·67	7·7	·84	6·9	1·0	...	...	...	...	...	...	...	...	...	...	7
18	·46	16	·59	14	·75	13	·93	12	1·1	...	...	...	...	...	...	...	...	
9·5	·48	8·3	·63	7·4	·80	6·6	·98	6·0	1·2	...	...	...	...	...	...	...	...	
13	·46	11	·60	10	·76	9·0	·94	8·1	1·1	...	...	...	...	...	...	...	...	
14	·46	12	·60	11	·76	9·7	·94	8·8	1·1	...	...	...	...	...	...	...	...	8
23	·42	20	·55	18	·69	16	·85	15	1·0	13	1·2	...	...	...	...	...	...	
12	·44	11	·57	9·5	·72	8·5	·89	7·8	1·1	7·1	1·3	...	...	...	...	...	...	
17	·42	14	·55	13	·69	12	·85	11	1·0	9·7	1·2	...	...	...	...	...	...	
17	·42	15	·55	13	·69	12	·85	11	1·0	9·9	1·2	...	...	...	...	...	...	8½
28	·38	25	·50	22	·63	20	·78	18	·94	16	1·1	15	1·3	...	...	...	...	
16	·40	14	·53	12	·66	11	·82	10	·99	9·2	1·2	8·5	1·4	...	...	...	...	
21	·38	18	·50	16	·63	15	·78	13	·94	12	1·1	11	1·3	...	...	...	...	
23	·38	20	·50	18	·63	16	·78	14	·94	13	1·1	12	1·3	...	...	...	...	9½
36	·35	31	·46	28	·58	25	·72	23	·87	21	1·0	19	1·2	18	1·4	...	...	

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.

For Explanation, see page 36.

Nominal Size. d × b	Weight per Foot.	Delivery.	Maximum Distributed Load.	Moment of Resistance.	12 ft. Safe Load.	12 ft. Defl'n.	14 ft. Safe Load.	14 ft. Defl'n.	16 ft. Safe Load.	16 ft. Defl'n.	18 ft. Safe Load.	18 ft. Defl'n.	20 ft. Safe Load.	20 ft. Defl'n.	22 ft. Safe Load.	22 ft. Defl'n.
Ins.	Lb.		Tons.	In-Tns.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.
	44·2	a*	23·3	374	21	·28	18	·38	16	·50	14	·64	12	·79	11	·95
	55·6	a	22·8	497	...	...	...	...	21	·48	18	·61	17	·75	15	·91
10 × 10	61·1	a*	33·8	519	29	·27	25	·37	22	·48	19	·61	17	·75	16	·91
	103	ar	61·3	880	49	·25	42	·34	37	·44	33	·55	29	·68	27	·83
	46·0	a	24·3	407	23	·27	19	·37	17	·48	15	·61	14	·75	12	·91
	59·5	a	24·6	553	...	...	...	...	23	·46	21	·58	18	·72	17	·87
10¼ × 10¼	63·6	a	35·2	566	31	·26	27	·35	24	·46	21	·58	19	·72	17	·87
	116	ar	71·7	1032	57	·23	49	·32	43	·42	38	·53	34	·65	31	·79
	51·4	a	26·9	488	...	...	23	·34	20	·45	18	·57	16	·70	15	·85
	67·7	a	27·3	679	...	...	...	...	...	...	25	·54	23	·67	21	·81
11 × 11	75·7	a*	41·4	722	40	·24	34	·33	30	·43	27	·54	24	·67	22	·81
	135	ar	81·1	1296	72	·22	62	·30	54	·39	48	·49	43	·61	39	·73
	58·9	a*	31·0	606	...	...	29	·32	25	·41	22	·52	20	·65	18	·78
	76·4	a	31·2	824	...	...	...	...	...	...	31	·51	28	·63	25	·76
12 × 12	81·2	a*	44·4	840	...	...	40	·31	35	·40	31	·51	28	·63	25	·76
	158	ar	96·3	1648	92	·20	78	·27	69	·36	61	·45	55	·56	50	·68
	65·8	a	35·8	715	...	...	34	·30	30	·39	26	·49	24	·61	22	·74
	81·4	a	35·3	928	...	...	...	...	...	...	34	·47	31	·59	28	·71
12½ × 12	90·3	a	51·4	984	...	...	47	·29	41	·38	36	·47	33	·59	30	·71
	166	ar	102	1832	102	·19	87	·26	76	·34	68	·43	61	·53	56	·64
	70·7	a	40·6	816	...	...	39	·28	34	·36	30	·46	27	·57	25	·69
	86·2	a	39·6	1040	...	...	...	...	...	...	39	·45	35	·55	32	·67
13½ × 12	91·6	a	54·6	1064	...	...	51	·27	44	·35	39	·45	35	·55	32	·67
	168	ar	108	1976	...	...	94	·24	82	·32	73	·40	66	·50	60	·60
	75·7	a	44·9	912	...	...	43	·26	38	·35	34	·44	30	·54	28	·65
	91·3	a	44·2	1160	...	...	...	...	...	...	43	·42	39	·52	35	·63
14 × 12	101	a*	62·3	1224	...	...	58	·26	51	·33	45	·42	41	·52	37	·63
	170	ar	112	2080	...	...	99	·23	87	·31	77	·39	69	·48	63	·58
	80·6	b	50·2	1032	...	...	49	·25	43	·32	38	·41	34	·51	31	·61
	96·3	b	49·1	1280	...	...	...	...	...	...	47	·40	43	·49	39	·60
15 × 12	102	b	65·8	1312	...	...	62	·24	55	·32	49	·40	44	·49	40	·60
	172	br	118	2224	...	...	106	·22	93	·29	82	·37	74	·46	67	·55
	84·9	a	52·6	1136	...	...	...	...	47	·31	42	·39	38	·48	34	·58
	101	a	54·2	1408	...	...	...	...	...	...	52	·38	47	·47	43	·57
16 × 12	110	a	69·3	1480	...	...	...	...	62	·30	55	·38	49	·47	45	·57
	172	ar	117	2328	...	...	111	·21	97	·28	86	·36	78	·44	71	·53

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.
—Continued.

24 ft.		26 ft.		28 ft.		30 ft.		32 ft.		36 ft.		40 ft.		44 ft.		48 ft.		52 ft.		Nominal Depth.
Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	
Tons	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Ins.
10	1·1	9·6	1·3	8·9	1·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
14	1·1	13	1·3	12	1·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
14	1·1	13	1·3	12	1·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10
24	·99	23	1·2	21	1·3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
11	1·1	10	1·3	9·7	1·5	9·0	1·8	...	...	...	...	...	...	...	...	...	...	...	...	
15	1·0	14	1·2	13	1·4	12	1·6	...	...	...	...	...	...	...	...	...	...	...	...	
16	1·0	14	1·2	13	1·4	13	1·6	...	...	...	...	...	...	...	...	...	...	...	...	10½
29	·94	26	1·1	25	1·3	23	1·5	22	1·7	...	...	...	...	...	...	...	...	...	...	
14	1·0	13	1·2	12	1·4	11	1·6	10	1·7	...	...	...	...	...	...	...	...	...	...	
19	·97	17	1·1	16	1·3	15	1·5	14	1·7	...	...	...	...	...	...	...	...	...	...	
20	·97	18	1·1	17	1·3	16	1·5	15	1·7	...	...	...	...	...	...	...	...	...	...	11
36	·87	33	1·0	31	1·2	29	1·4	27	1·5	24	2·0	...	...	...	...	...	...	...	...	
17	·93	16	1·1	14	1·3	13	1·5	13	1·7	11	2·1	...	...	...	...	...	...	...	...	
23	·90	21	1·1	20	1·2	18	1·4	17	1·6	15	2·0	...	...	...	...	...	...	...	...	
23	·90	21	1·1	20	1·2	19	1·4	17	1·6	16	2·0	...	...	...	...	...	...	...	...	12
46	·80	42	·94	39	1·1	37	1·3	34	1·4	31	1·8	27	2·2	...	...	...	...	...	...	
20	·88	18	1·0	17	1·2	16	1·4	15	1·6	13	2·0	12	2·4	...	...	...	...	...	...	
26	·84	24	·99	22	1·1	21	1·3	19	1·5	17	1·9	15	2·3	...	...	...	...	...	...	
27	·84	25	·99	23	1·1	22	1·3	20	1·5	18	1·9	16	2·3	...	...	...	...	...	...	12½
51	·76	47	·89	44	1·0	41	1·2	38	1·3	34	1·7	31	2·1	28	2·5	...	...	...	...	
23	·82	21	·96	19	1·1	18	1·3	17	1·5	15	1·8	14	2·3	12	2·7	...	...	...	...	
29	·79	27	·93	25	1·1	23	1·2	22	1·4	19	1·8	17	2·2	16	2·7	...	...	...	...	
30	·79	27	·93	25	1·1	24	1·2	22	1·4	20	1·8	18	2·2	16	2·7	...	...	...	...	13½
55	·72	51	·84	47	·98	44	1·1	41	1·3	37	1·6	33	2·0	30	2·4	27	2·9	...	...	
25	·78	23	·91	22	1·1	20	1·2	19	1·4	17	1·7	15	2·2	14	2·6	...	...	...	...	
32	·75	30	·88	28	1·0	26	1·2	24	1·3	21	1·7	19	2·1	18	2·5	...	...	...	...	
34	·75	31	·88	29	1·0	27	1·2	25	1·3	23	1·7	20	2·1	19	2·5	...	...	...	...	14
58	·69	53	·81	50	·94	46	1·1	43	1·2	39	1·6	35	1·9	32	2·3	29	2·8	27	3·2	
29	·73	26	·86	25	·99	23	1·1	21	1·3	19	1·6	17	2·0	16	2·4	14	2·9	...	...	
36	·71	33	·83	30	·97	28	1·1	27	1·3	24	1·6	21	2·0	19	2·4	18	2·8	...	...	
36	·71	34	·83	31	·97	29	1·1	27	1·3	24	1·6	22	2·0	20	2·4	18	2·8	...	...	15
62	·66	57	·77	53	·89	49	1·0	46	1·2	41	1·5	37	1·8	34	2·2	31	2·6	29	3·1	
32	·70	29	·82	27	·95	25	1·1	24	1·2	21	1·6	19	1·9	17	2·3	16	2·8	15	3·3	
39	·68	36	·79	34	·92	31	1·1	29	1·2	26	1·5	23	1·9	21	2·3	20	2·7	18	3·2	
41	·68	38	·79	35	·92	33	1·1	31	1·2	27	1·5	25	1·9	22	2·3	21	2·7	19	3·2	16
65	·63	60	·74	55	·86	52	·99	48	1·1	43	1·4	39	1·8	35	2·1	32	2·5	30	3·0	

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.

For Explanation, see page 36.

Nominal Size. d × b	Weight per Foot.	Delivery.	Maximum Distributed Load.	Moment of Resistance.	16 ft. Safe Load.	16 ft. Defl'n.	18 ft. Safe Load.	18 ft. Defl'n.	20 ft. Safe Load.	20 ft. Defl'n.	22 ft. Safe Load.	22 ft. Defl'n.	24 ft. Safe Load.	24 ft. Defl'n.	26 ft. Safe Load.	26 ft. Defl'n.
Ins.	Lb.		Tons.	In-Tns.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.
17×12	90·4	*b*	58·7	1288	54	·29	48	·37	43	·45	39	·55	36	·65	33	·77
	107	*b*	60·2	1568	...	...	58	·36	52	·44	48	·53	44	·64	40	·75
	112	*b*	73·6	1600	67	·28	59	·36	53	·44	48	·53	44	·64	41	·75
	175	*br*	124	2504	104	·26	93	·34	83	·41	76	·50	70	·60	64	·70
18×12	96·3	*a*	64·7	1432	60	·27	53	·35	48	·43	43	·52	40	·62	37	·73
	113	*a*	66·5	1744	...	...	65	·34	58	·42	53	·50	48	·60	45	·70
	122	*a*	83·6	1824	76	·27	68	·34	61	·42	55	·50	51	·60	47	·70
	175	*ar*	124	2640	110	·25	98	·32	88	·40	80	·48	73	·57	68	·67
19×12	102	*c*	71·7	1600	67	·26	59	·33	53	·40	48	·49	44	·58	41	·68
	119	*c*	73·3	1920	...	...	71	·32	64	·39	58	·47	53	·57	49	·67
	124	*c*	88·3	1952	80	·25	72	·32	65	·39	59	·47	54	·57	50	·67
	178	*cr*	130	2616	117	·24	104	·30	94	·38	85	·44	78	·54	72	·64
20×12	108	*a*	78·3	1768	74	·25	65	·31	59	·38	54	·47	49	·55	45	·65
	125	*a*	80·3	2112	...	...	78	·30	70	·38	64	·45	59	·54	54	·63
	135	*a*	99·2	2208	92	·24	82	·30	74	·38	67	·45	61	·54	57	·63
	180	*ar*	136	2968	124	·23	110	·29	99	·36	90	·44	82	·52	76	·61
22×12	113	*c*	86·5	2024	84	·22	75	·28	67	·35	61	·42	56	·50	52	·59
	132	*c*	91·8	2448	...	...	91	·28	82	·34	74	·41	68	·49	63	·58
	139	*c*	109	2488	104	·22	92	·28	83	·34	75	·41	69	·49	64	·58
	185	*cr*	149	3344	139	·21	124	·27	111	·33	101	·40	93	·47	86	·56
24×12	124	*b*	102	2392	100	·20	89	·26	80	·32	72	·39	66	·46	61	·54
	141	*b*	104	2816	...	...	104	·25	94	·31	85	·38	78	·45	72	·53
	152	*b*	127	2944	123	·20	109	·25	98	·31	89	·38	82	·45	75	·53
	191	*br*	161	3696	154	·19	137	·25	123	·30	112	·37	103	·44	95	·51
26×12	128	*b*	110	2648	110	·19	98	·24	88	·29	80	·36	74	·42	68	·50
	157	*b*	137	3256	136	·18	121	·23	109	·29	99	·35	90	·42	83	·49
	196	*br*	174	4088	170	·18	151	·23	136	·28	124	·34	114	·41	105	·48
28×12	141	*b*	128	3104	...	...	115	·22	103	·27	94	·33	86	·39	80	·46
	171	*b*	157	3768	157	·17	140	·22	126	·27	114	·32	105	·39	97	·45
	201	*br*	186	4448	185	·17	165	·21	148	·26	135	·32	124	·38	114	·44
30×12	145	*b*	137	3392	...	...	126	·21	113	·25	103	·31	94	·37	87	·43
	176	*b*	168	4120	...	...	153	·20	137	·25	125	·30	114	·36	106	·42
	207	*br*	199	4856	...	...	180	·20	162	·25	147	·30	135	·35	125	·42
32×12	159	*b*	157	3944	...	...	146	·19	131	·24	120	·29	110	·34	101	·40
	180	*b*	179	4472	...	...	166	·19	149	·23	136	·28	124	·34	115	·40
	212	*br*	212	5272	...	...	195	·19	176	·23	160	·28	146	·33	135	·39

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.
—Continued.

28 ft.		30 ft.		32 ft.		36 ft.		40 ft.		44 ft.		48 ft.		52 ft.		56 ft.		60 ft.		64 ft.		Nominal Depth.
Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	
Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Tns.	Ins.	Ins.
31	·89	29	1·0	27	1·2	24	1·5	21	1·8	20	2·2	18	2·6	17	3·1	...	...	...	...	...	...	
37	·86	35	·99	33	1·1	29	1·4	26	1·8	24	2·1	22	2·5	20	3·0	...	...	...	...	...	...	
38	·86	36	·99	33	1·1	30	1·4	27	1·8	24	2·1	22	2·5	21	3·0	...	...	...	...	...	...	17
60	·81	56	·93	52	1·1	46	1·3	42	1·7	38	2·0	35	2·4	32	2·8	...	...	...	...	...	...	
34	·84	32	·97	30	1·1	27	1·4	24	1·7	22	2·1	20	2·5	18	2·9	17	3·4	16	3·9	...	...	
42	·82	39	·94	36	1·1	32	1·4	29	1·7	26	2·0	24	2·4	22	2·8	21	3·3	19	3·8	...	...	
43	·82	41	·94	38	1·1	34	1·4	30	1·7	28	2·0	25	2·4	23	2·8	22	3·3	20	3·8	...	...	18
63	·78	59	·89	55	1·0	49	1·3	44	1·6	40	1·9	37	2·3	34	2·7	31	3·1	29	3·6	27	4·1	
38	·79	36	·91	33	1·0	30	1·3	27	1·6	24	2·0	22	2·3	21	2·7	19	3·2	18	3·6	17	4·1	
46	·77	43	·89	40	1·0	36	1·3	32	1·6	29	1·9	27	2·3	25	2·7	23	3·1	21	3·6	20	4·0	
46	·77	43	·89	41	1·0	36	1·3	33	1·6	30	1·9	27	2·3	25	2·7	23	3·1	22	3·6	20	4·0	19
67	·74	63	·85	59	·96	52	1·2	47	1·5	43	1·8	39	2·2	36	2·5	34	2·9	31	3·4	29	3·8	
42	·75	39	·87	37	·99	33	1·2	29	1·5	27	1·9	25	2·2	23	2·6	21	3·0	20	3·5	18	3·9	
50	·74	47	·84	44	·96	39	1·2	35	1·5	32	1·8	29	2·2	27	2·5	25	2·9	23	3·4	22	3·8	
53	·74	49	·84	46	·96	41	1·2	37	1·5	33	1·8	31	2·2	28	2·5	26	2·9	25	3·4	23	3·8	20
71	·71	66	·81	62	·92	55	1·2	49	1·5	45	1·8	41	2·1	38	2·5	35	2·8	33	3·3	31	3·7	
48	·68	45	·78	42	·89	37	1·1	34	1·4	31	1·7	28	2·0	26	2·4	24	2·7	22	3·1	21	3·6	
58	·67	54	·76	51	·87	45	1·1	41	1·4	37	1·7	34	2·0	31	2·3	29	2·7	27	3·1	25	3·4	
59	·67	55	·76	52	·87	46	1·1	41	1·4	38	1·7	35	2·0	32	2·3	30	2·7	28	3·1	26	3·4	22
80	·64	74	·74	70	·84	62	1·1	56	1·3	51	1·6	46	1·9	43	2·2	40	2·6	37	3·0	35	3·4	
57	·63	53	·72	50	·82	44	1·0	40	1·3	36	1·5	33	1·8	31	2·2	28	2·5	27	2·9	25	3·3	
67	·61	63	·70	59	·80	52	1·0	47	1·3	43	1·5	39	1·8	36	2·1	34	2·5	31	2·8	29	3·2	
70	·61	65	·70	61	·80	54	1·0	49	1·3	45	1·5	41	1·8	38	2·1	35	2·5	33	2·8	31	3·2	24
88	·60	82	·69	77	·78	68	·99	62	1·2	56	1·5	51	1·8	47	2·1	44	2·4	41	2·7	38	3·1	
63	·58	59	·66	55	·75	49	·95	44	1·2	40	1·4	37	1·7	34	2·0	32	2·3	29	2·6	28	3·0	
78	·57	72	·65	68	·74	60	·93	54	1·2	49	1·4	45	1·7	42	1·9	39	2·3	36	2·6	34	3·0	26
97	·55	91	·63	85	·72	76	·91	68	1·1	62	1·4	57	1·6	52	1·9	49	2·2	45	2·5	43	2·9	
74	·53	69	·61	65	·70	57	·88	52	1·1	47	1·3	43	1·6	40	1·8	37	2·1	34	2·5	32	2·8	
90	·53	84	·60	78	·69	70	·87	63	1·1	57	1·3	52	1·5	48	1·8	45	2·1	42	2·4	39	2·7	28
106	·52	99	·59	93	·67	82	·85	74	1·1	67	1·3	62	1·5	57	1·8	53	2·1	49	2·4	46	2·7	
81	·50	75	·57	71	·65	63	·82	57	1·0	51	1·2	47	1·5	43	1·7	40	2·0	38	2·3	35	2·6	
98	·49	92	·56	86	·64	76	·81	69	1·0	62	1·2	57	1·4	53	1·7	49	2·0	46	2·3	43	2·6	30
116	·48	108	·55	101	·63	90	·80	81	·98	74	1·2	67	1·4	62	1·7	58	1·9	54	2·2	51	2·5	
94	·46	88	·53	82	·61	73	·77	66	·95	60	1·1	55	1·4	51	1·6	47	1·9	44	2·1	41	2·4	
106	·46	99	·53	93	·60	83	·76	75	·94	68	1·1	62	1·4	57	1·6	53	1·8	50	2·1	47	2·4	32
126	·45	117	·52	110	·59	98	·75	88	·92	80	1·1	73	1·3	68	1·6	63	1·8	59	2·1	55	2·4	

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.

Nominal Size. d × b	Weight per Foot.	Delivery.	Maximum Distributed Load.	Moment of Resistance.	18 ft. Safe Load.	18 ft. Defl'n.	20 ft. Safe Load.	20 ft. Defl'n.	22 ft. Safe Load.	22 ft. Defl'n.	24 ft. Safe Load.	24 ft. Defl'n.	26 ft. Safe Load.	26 ft. Defl'n.	28 ft. Safe Load.	28 ft. Defl'n.
Ins.	Lb.		Tons.	In-Tns.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.
34 × 12	174	*c*	177	4536	168	·18	151	·22	137	·27	126	·32	116	·38	108	·44
	196	*c*	201	5096	189	·18	170	·22	154	·27	142	·32	131	·37	121	·43
	218	*cr*	224	5656	209	·18	189	·22	171	·26	157	·32	145	·37	135	·43
36 × 12	179	*c*	188	4880	181	·17	163	·21	148	·25	136	·30	125	·36	116	·41
	201	*c*	213	5488	203	·17	183	·21	166	·25	152	·30	141	·35	131	·41
	223	*cr*	237	6088	225	·17	203	·21	184	·25	169	·30	156	·35	145	·40
38 × 12	183	*c*	199	5240	194	·16	175	·20	159	·24	146	·29	134	·34	125	·39
	206	*c*	224	5888	218	·16	196	·20	178	·24	164	·28	151	·33	140	·39
	229	*cr*	250	6528	242	·16	218	·20	198	·24	181	·28	167	·33	155	·38
40 × 12	188	*b*	210	5600	207	·15	187	·19	170	·23	156	·27	144	·32	133	·37
	211	*b*	233	6296	233	·15	210	·19	191	·23	175	·27	161	·32	150	·37
	234	*br*	264	6984	259	·15	233	·19	212	·23	194	·27	179	·31	166	·36

1. SAFE LOADS.

The tabulated safe loads are based on a working stress of 8 tons per square inch. They include the weight of the beam and are calculated by the usual formula for a uniformly distributed load on a beam freely supported at both ends, which here resolves itself into:—Safe load in tons × span in feet (centre to centre of bearings) = $5\frac{1}{3}$ × section modulus.

2. MAXIMUM DISTRIBUTED LOADS.

These equal 8 × depth (d) × web thickness (t) and correspond to a maximum shear stress of $4\frac{1}{2}$ tons per square inch, approx.

3. MOMENT OF RESISTANCE.

The tabulated figures = $8 \times Z_x$.

4. DEFLECTIONS.

The tabulated deflections are calculated by the usual formula, *viz.*:—Deflection in inches = $fl^2 \div 4{\cdot}8\,dE$, in which d = depth of girder, l = span of girder, both in inches, and E = Elastic Modulus (13,000 tons per square inch). Deflections to the right of the zig-zag line exceed 1/325th of the span, the limit allowed by B.S.S. 449. If the tabular load is decreased, the deflection will be reduced in the same proportion.

5. CONCENTRATED LOADS.

For these, calculate the Maximum Bending Moment (inch-tons) and select beam from the "Moment of Resistance" column.

B.F. BEAMS, GREY PROCESS: AS GIRDERS.

SAFE DISTRIBUTED LOADS, WITH DEFLECTIONS: 8 TONS STRESS.
—Continued.

30 ft.		32 ft.		36 ft.		40 ft.		44 ft.		48 ft.		52 ft.		56 ft.		60 ft.		64 ft.		Nominal Depth.
Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	Safe Load.	Defl'n.	
Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Tons.	Ins.	Ins.
101	·50	94	·57	84	·72	76	·89	69	1·1	63	1·3	58	1·5	54	1·7	50	2·0	47	2·3	
113	·50	106	·56	94	·71	85	·88	77	1·1	71	1·3	65	1·5	61	1·7	57	2·0	53	2·3	**34**
126	·49	118	·56	105	·71	94	·88	86	1·1	79	1·3	73	1·5	67	1·7	63	2·0	59	2·2	
108	·47	102	·54	90	·68	81	·84	74	1·0	68	1·2	63	1·4	58	1·6	54	1·9	51	2·2	
122	·47	114	·53	102	·68	91	·83	83	1·0	76	1·2	70	1·4	65	1·6	61	1·9	57	2·1	**36**
135	·47	127	·53	113	·67	101	·83	92	1·0	85	1·2	78	1·4	72	1·6	68	1·9	63	2·1	
116	·45	109	·51	97	·65	87	·80	79	·96	73	1·1	67	1·3	62	1·6	58	1·8	55	2·0	
131	·44	123	·51	109	·64	98	·79	89	·96	82	1·1	75	1·3	70	1·5	65	1·8	61	2·0	**38**
145	·44	136	·50	121	·63	109	·78	99	·95	91	1·1	84	1·3	78	1·5	73	1·8	68	2·0	
124	·42	117	·48	104	·61	93	·76	85	·91	78	1·1	72	1·3	67	1·5	62	1·7	58	1·9	
140	·42	131	·48	117	·61	105	·75	95	·91	87	1·1	81	1·3	75	1·5	70	1·7	66	1·9	**40**
155	·42	145	·48	129	·60	116	·74	106	·90	97	1·1	90	1·3	83	1·5	78	1·7	73	1·9	

6. WEIGHTS PER FOOT.

The various weights listed for each section are:—

(i) Up to 24″ × 12″, the DIE, DIL, DIN and DIR weights respectively, as explained on page 21.
(ii) Above 24″ × 12″, the DIE, DIN and DIR weights respectively.

These are all obtainable with equal facility from the mills, except that the DIR (maximum) weights can only be supplied in the minimum quantities specified in the table on page 286; the weights readily obtainable in small lots from local U.K. stocks are those marked with an asterisk in the "Delivery" column. For most purposes, the minimum weights should be preferred, as being the most economical.

7. INTERMEDIATE WEIGHTS.

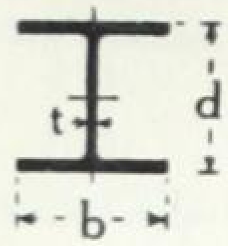
All sections can be rolled to weights intermediate between the tabulated minima and maxima, subject to the conditions explained on pages 11 and 286.

8. DELIVERY.

The meaning of the symbols is as follows, but see page 6:—

(*) Stocked in the United Kingdom.
(*a*) Average rolling dates 3–4 weeks.
(*b*) „ „ „ 4–6 „
(*c*) „ „ „ 6–8 „

9. DESCRIBE WHEN ORDERING as "Broad Flange Beams, Grey Process, ...″ × ...″ × ...lb. nominal." See also page 267 ("Tests").



SOME SPECIAL PROPERTIES OF

BROAD FLANGE BEAMS, GREY PROCESS.

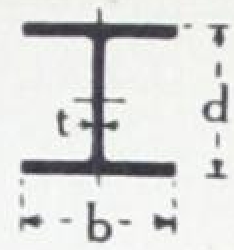
[For the minimum and maximum weights of each section.]

Nominal Size.	Weight per Foot.	Ratio of Fillet Stress to Extreme Fibre Stress.	Web Thickness.	Web Area.	Nett Depth of Web.	Safe Principal Compressive Stress.	Safe Column Stress on Web and Load per 1" run.	
d × b			t	d × t	C	Tons per square inch.	Stress : P_1	Load : $P_1 \times t$
Inches.	Lb.		Inches.	Inches.^{2}	Inches.			Tons.
4 × 4	11·0	·595	·20	0·74	2·2	5·88	5·76	1·15
„	23·2	·500	·39	1·72	2·2	5·96	5·94	2·32
5 × 5	13·2	·664	·20	0·90	3·0	5·78	5·56	1·11
„	27·9	·576	·39	2·03	3·0	5·94	5·89	2·30
5½ × 5½	16·4	·696	·22	1·14	3·6	5·74	5·46	1·20
„	47·9	·561	·63	4·09	3·6	5·96	5·94	3·74
6 × 6	17·6	·718	·22	1·23	4·0	5·67	5·33	1·17
„	51·3	·678	·63	4·35	4·0	5·94	5·89	3·71
6¼ × 6¼	20·0	·693	·24	1·42	4·1	5·71	5·41	1·30
„	56·0	·571	·63	4·54	4·1	5·95	5·92	3·73
7 × 7	24·8	·718	·26	1·77	4·9	5·64	5·28	1·37
„	63·0	·614	·63	5·04	4·9	5·94	5·88	3·70
8 × 8	30·1	·724	·28	2·10	5·4	5·62	5·24	1·47
„	71·6	·627	·63	5·48	5·4	5·93	5·85	3·69
8½ × 8½	34·5	·749	·29	2·41	6·2	5·54	5·07	1·47
„	78·8	·658	·63	5·92	6·2	5·90	5·81	3·66
9½ × 9½	40·9	·743	·31	2·79	6·7	5·53	5·04	1·56
„	92·2	·654	·67	6·83	6·7	5·90	5·80	3·89
10 × 10	44·2	·754	·31	2·91	7·1	5·46	4·93	1·54
„	103	·657	·71	7·67	7·1	5·90	5·80	4·12
10¼ × 10¼	46·0	·763	·31	3·04	7·5	5·41	4·81	1·49
„	116	·660	·79	8·93	7·5	5·91	5·82	4·60
11 × 11	51·4	·765	·32	3·36	8·0	5·36	4·71	1·51
„	135	·658	·83	10·13	8·0	5·90	5·81	4·82
12 × 12	58·9	·774	·34	3·88	8·8	5·32	4·64	1·58
„	158	·667	·91	12·01	8·8	5·90	5·81	5·29
12½ × 12	65·8	·768	·37	4·48	9·3	5·36	4·73	1·75
„	166	·663	·91	12·74	9·3	5·89	5·79	5·27
13½ × 12	70·7	·775	·39	5·07	10·1	5·33	4·66	1·82
„	168	·681	·91	13·47	10·1	5·88	5·76	5·24
14 × 12	75·7	·776	·41	5·62	10·6	5·32	4·64	1·90
„	170	·689	·91	14·01	10·6	5·86	5·73	5·21
15 × 12	80·6	·782	·43	6·28	11·4	5·28	4·58	1·97
„	172	·704	·91	14·74	11·4	5·84	5·69	5·18
16 × 12	84·9	·788	·43	6·58	12·0	5·20	4·42	1·90
„	172	·715	·87	14·70	12·0	5·81	5·61	4·88

SOME SPECIAL PROPERTIES OF

BROAD FLANGE BEAMS, GREY PROCESS.—Cont'd.

[For the minimum and maximum weights of each section.]



Nominal Size.	Weight per Foot.	Ratio of Fillet Stress to Extreme Fibre Stress.	Web Thickness.	Web Area.	Nett Depth of Web.	Safe Principal Compressive Stress.	Safe Column Stress on Web and Load per 1" run.	
d × b			t	d × t	C	Tons per square inch.	Stress : P_1	Load : $P_1 \times t$
Inches.	Lb.		Inches.	Inches.²	Inches.			Tons.
17 ×12	90·4	·799	·45	7·33	13·0	5·15	4·33	1·95
„	175	·731	·87	15·49	13·0	5·77	5·55	4·83
18 ×12	96·3	·797	·47	8·08	13·7	5·14	4·32	2·03
„	175	·734	·83	15·52	13·7	5·73	5·45	4·52
19 ×12	102	·802	·49	8·97	14·7	5·08	4·22	2·07
„	178	·747	·83	16·27	14·7	5·69	5·37	4·46
20 ×12	108	·804	·51	9·79	15·4	5·06	4·19	2·14
„	180	·754	·83	17·01	15·4	5·65	5·30	4·40
22 ×12	113	·821	·51	10·81	17·4	4·82	3·78	1·93
„	185	·775	·83	18·59	17·4	5·56	5·11	4·24
24 ×12	124	·825	·55	12·70	19·1	4·79	3·73	2·05
„	191	·786	·83	20·17	19·1	5·47	4·94	4·10
26 ×12	128	·833	·55	13·80	21·0	4·54	3·36	1·85
„	196	·802	·83	21·75	21·0	5·35	4·70	3·90
28 ×12	141	·840	·59	15·99	22·8	4·50	3·31	1·95
„	201	·812	·83	23·24	22·8	5·24	4·50	3·73
30 ×12	145	·849	·59	17·17	24·7	4·26	3·00	1·77
„	207	·824	·83	24·90	24·7	5·10	4·25	3·53
32 ×12	159	·855	·63	19·66	26·7	4·23	2·97	1·87
„	212	·835	·83	26·56	26·7	4·95	4·00	3·32
34 ×12	174	·854	·67	22·18	28·3	4·23	2·98	2·00
„	218	·837	·83	28·05	28·3	4·83	3·80	3·15
36 ×12	179	·862	·67	23·52	30·2	4·01	2·72	1·82
„	223	·846	·83	29·63	30·2	4·66	3·55	2·95
38 ×12	183	·868	·67	24·86	32·2	3·79	2·49	1·67
„	229	·854	·83	31·29	32·2	4·49	3·30	2·74
40 ×12	188	·874	·67	26·20	34·2	3·57	2·28	1·53
„	234	·861	·83	32·95	34·2	4·32	3·08	2·56

The above special properties are used in investigating the effect of heavy concentrated loads, in the manner explained on page 61.

The "Safe Principal Compressive Stress" is the safe stress by Fidler's formula for a strut with fixed ends of length equal to $\frac{1}{2}l$ (Fig. 1).

The "Safe Column Stress" is by the same formula for a strut of length c (Fig. 2).

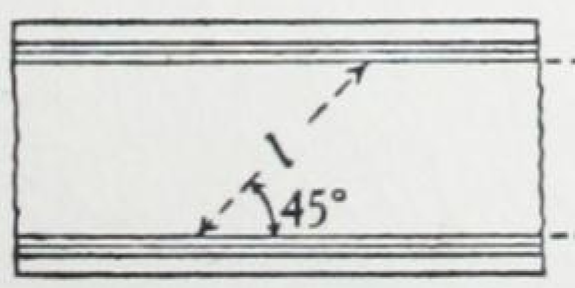


Fig. 1.

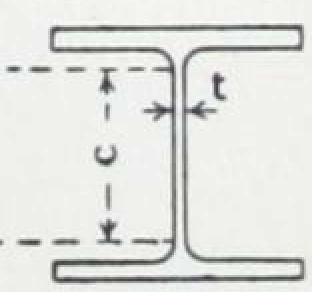


Fig. 2.

NOTES ON GIRDERS

PRINTED ELSEWHERE

Safe loads : see separate chapters.

Joists in concrete, pages 225–229.

SUMMARY OF GIRDER SECTIONS

EXPLANATION.

Tables of safe distributed loads for Broad Flange Beams and Joists will be found in their respective chapters.

An alternative procedure is to calculate the Bending Moment, and thence the required Section Modulus (Bending Moment divided by working stress)[1]; then to select a suitable section from the following table, in which the various sections are ranged in order of Section Modulus. It is needless to say that shear, deflection, and lateral stiffness may also have to be considered.

Where economy is the main consideration, it is necessary to bear in mind the considerable difference in cost per ton between plain rolled steel beams and built-up girders.

The tabulated weights allow for rivet heads, but not for stiffeners or separators. Rivet holes (in the tension flange) are allowed for in the tabulated Section Moduli for plated beams. In the listed depths, rivet heads are disregarded.

The delivery symbols are to be interpreted as follows :—

- * = Stocked in London and elsewhere.
- *a* = Average rollings 3–4 weeks.
- *b* = ,, ,, 4–6 ,,
- *c* = ,, ,, 6–8 ,,
- *i* = Intermediate weight, 18 to 36 tons minimum (see page 286).
- *r* = Maximum weight, 3 to 9 tons minimum (see page 286).
- *s* = Usually in stock.
- *x* = Frequently rolled.
- *y* = Rollings irregular.

N.B.—These indications of the time required for delivery refer to normal pre-war conditions. For the present position (1948), see note at foot of page 6.

[1] Thus, for a uniformly distributed load of W (tons), ends freely supported, and span L (feet), the requisite Section Modulus will be 1/5 WL for a working stress of $7\frac{1}{2}$ tons, or 3/16 WL for a working stress of 8 tons per square inch. For other conditions of loading, see formulæ for Bending Moment on pages 45 to 48.

SUMMARY OF GIRDER SECTIONS.

IN ORDER OF CARRYING CAPACITY (SECTION MODULUS).

For Explanation, see page 42.

Section Modulus.	Depth and Breadth.		Weight per Foot.	Delivery.	Consisting of	Code Word.	Properties on page	Section Modulus.	Depth and Breadth.		Weight per Foot.	Delivery.	Consisting of	Code Word.	Properties on page
z	d	b						z	d	b					
Ins.*	Ins.	Ins.						Ins.*	Ins.	Ins.					
1·11	3	1·5	4	ys	Joist	ACORN	172	57·1	15	5	42	ys	Joist	ARIAN	172
1·83	4	1·75	5	xs	,,	ADAGE	172	57·7	10	8	55	xs	,,	ANODE	172
2·54	3	3	8½	xs	,,	ACRID	172	59·1	9·1	8·8	63	ai	BF Beam	YOHYT	16
2·83	4·75	1·75	6½	ys	,,	ADULT	172	59·4	9·4	9·4	59	a	,,	BAEJM	17
3·89	4	3	10	x	,,	ADIEU	172	60·5	8·7	8·1	71½	ar	,,	YOAMS	16
4·25	3·7	3·9	11	a	BF Beam	YOOPO	16	61·0	10·5	10·9	51½	a	,,	YOPEF	17
5·47	5	3	11	xs	Joist	AEGIS	172	62·1	9·8	9·8	56	a	,,	BETDE	17
5·76	3·9	3·9	14·2	a	BF Beam	BEAHL	16	62·6	12	6	54	xs	Joist	APPLE	172
5·83	3·9	3·9	14·8	a	,,	BAABA	16	62·9	14	6	46	ys	,,	ARECA	172
6·40	4·5	4·7	13·2	a	,,	YOOPT	16	64·9	9·8	9·8	61	a*	BF Beam	BAELP	17
8·63	4·7	4·7	17	a	,,	BEANY	16	65·6	15	6	45	xs	Joist	ARROW	172
8·75	4·7	4·7	17·8	a	,,	BAANG	16	69·1	10·2	10·2	60	a	BF Beam	BETJY	17
9·33	4·4	4·1	23·2	ar	,,	YOACH	16	70·7	10·2	10·2	64	a	,,	BAEZD	17
9·33	5·2	5·4	16½	a	,,	YOORY	16	72·6	7·9	15·7	87	a*	2 BF Beams	BACYL	16
10·0	5	4·5	20	x	Joist	AFIRE	172	74	9·4	8·9	79	ar	BF Beam	YOANT	16
10·9	5·6	5·8	18	a*	BF Beam	YOOSH	16	76	14	6	57	ys	Joist	ARETE	172
11·3	7	4	16	xs	Joist	AIRER	172	76	11·4	11·7	59	a*	BF Beam	YOPGA	17
11·6	6	4·5	20	xs	,,	AGILE	172	76	9·8	9·6	75	ai	,,	YOIPY	17
12·9	5·5	5·5	21	a	BF Beam	BEBMO	16	77	16	6	50	xs	Joist	ARTLY	172
12·9	5·9	6·2	20	a	,,	YOOTU	16	81	12	8	65	xs	,,	APRON	172
13·2	5·5	5·5	23	a*	,,	BABAD	16	85	11	11	68	a	BF Beam	BETYJ	17
13·9	5·2	4·9	28	ar	,,	YOADS	16	88	10·3	10	82½	ai	,,	YOJIR	17
13·9	8	4	18	xs	Joist	AISLE	172	89	8·7	17·3	96	a*	2 BF Beams	BADOK	16
14·5	6	5	25	xs	,,	AGONY	172	89	12·1	11·7	66	a	BF Beam	YOPHO	17
15·0	5·9	5·9	23	a	BF Beam	BEBYF	16	90	11	11	76	a*	,,	BAHEL	17
15·4	5·9	5·9	25	a*	,,	BABEF	16	91	16	6	62	ys	Joist	ASHEN	172
18·0	9	4	21	xs	Joist	AMASS	172	93	18	6	55	xs	,,	ATAXY	172
18·4	6·3	6·3	26	a	BF Beam	BECAK	16	94	10·2	9·7	92	ar	BF Beam	YOARY	17
19·5	6·8	7·0	25	a*	,,	YOOVI	16	100	10·8	10·4	90	ai	,,	YOJVY	17
20·1	6·3	6·3	31	a	,,	BABHO	16	101	14	8	70	y	Joist	ARGOL	172
22·3	8	5	28	xs	Joist	ALDER	172	102	13	11·7	71	a	BF Beam	YOPIN	18
24·5	10	4·5	25	xs	,,	AMUSE	172	103	11·8	11·8	76	a	,,	BEVEF	17
24·9	7·5	7·8	30	a*	BF Beam	YOOWO	16	105	11·8	11·8	81	a*	,,	BAKEN	17
25·3	7·1	7·1	32	a	,,	BEDEM	16	110	10·8	10·1	103	ar	,,	YOASZ	17
26·0	7·1	7·1	35	a*	,,	BACGE	16	114	13·7	11·7	76	a	,,	YOPJU	18
26·4	5·5	11	47	a*	2 BF Beams	BABAD	16	116	12·6	11·8	81	a	,,	BEVHO	17
28·0	6·5	5·8	48	ar	BF Beam	YOAGM	16	119	9·4	18·9	117	a	2 BF Beams	BAEJM	17
28·8	8	6	35	xs	Joist	ALLAH	172	122	16	8	75	ys	Joist	ASTER	172
29·1	10	5	30	xs	,,	ANENT	172	123	20	6·5	65	xs	,,	AUGHT	172
30·8	5·9	11·8	50	a*	2 BF Beams	BABEF	16	123	12·6	11·8	90	a	BF Beam	BAKIP	17
32·0	8·3	8·5	34½	a	BF Beam	YOOKS	16	126	11·6	11·2	105	ai	,,	YOKUV	17
32·3	6·9	6·2	51	ar	,,	YOAGT	16	128	18	7	75	xs	Joist	ATLAS	172
33·6	7·9	7·9	38	a	,,	BEIZK	16	129	11·3	10·6	116	ar	BF Beam	YOAWD	17
36·3	7·9	7·9	44	a*	,,	BACYL	16	130	13·4	11·8	86	a	,,	BEVIG	18
36·7	12	5	32	x	Joist	AORTA	172	130	14·6	11·7	85	b	,,	YOPLY	18
37·3	7·2	7·6	56	ar	BF Beam	YOAHN	16	130	9·8	19·7	122	a*	2 BF Beams	BAELP	17
40·2	6·3	12·6	61½	a	2 BF Beams	BABHO	16	133	13·4	11·8	92	a	BF Beam	BAKMA	18
41·0	10	6	40	xs	Joist	ANKLE	16	141	10·2	20·5	127	a	2 BF Beams	BAEZD	17
41·2	9	9·3	41	a	BF Beam	YOOZA	17	142	15·3	11·7	85	a	BF Beam	YOPOC	18
43·6	8·7	8·7	45	a	,,	BERBE	16	144	18	8	80	y	Joist	ATONE	172
43·6	13	5	35	xs	Joist	ARBOR	172	145	14·2	11·8	91	a	BF Beam	BEVKY	18
44·7	8·7	8·7	48	a*	BF Beam	BADOK	16	152	22	7	75	xs	Joist	AWAKE	172
46·3	9	7	50	xs	Joist	AMITY	172	153	14·2	11·8	101	a*	BF Beam	BALEP	18
46·7	9·4	9·7	44	a*	BF Beam	YOPAJ	17	155	12·5	12	120	ai	,,	YOLIT	17
47·9	8	7·4	63	ar	,,	YOAJP	16	160	15	11·8	96	b	,,	BEVUJ	18
48·1	8·3	8	57½	ai	,,	YOHPE	16	161	16·3	11·7	90	b	,,	YOPPE	18
50·9	9·8	10·1	46	a	,,	YOPBI	17	162	12·2	11·4	135	ar	,,	YOBAH	17
52·0	7·1	14·2	69½	a*	2 BF Beams	BACGE	16	164	15	11·8	102	b	,,	BALRO	18
52·6	12	6	44	xs	Joist	APHIS	172	167	20	7·5	89	xs	Joist	AVIAN	172
55·5	9·4	9·4	52	a	BF Beam	BETAC	17	175	13·3	12	128	ai	BF Beam	YOLSE	17

Cleats, &c.
Column Loads.
Column Notes.
Caps, Bases.
Poles, Piles.
I
[●
<T
Rivets, Bolts.
Roofs, Concrete
Welding
Plates, Inertia.
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

SUMMARY OF GIRDER SECTIONS.—Continued.

IN ORDER OF CARRYING CAPACITY (SECTION MODULUS).

For Explanation, see page 42.

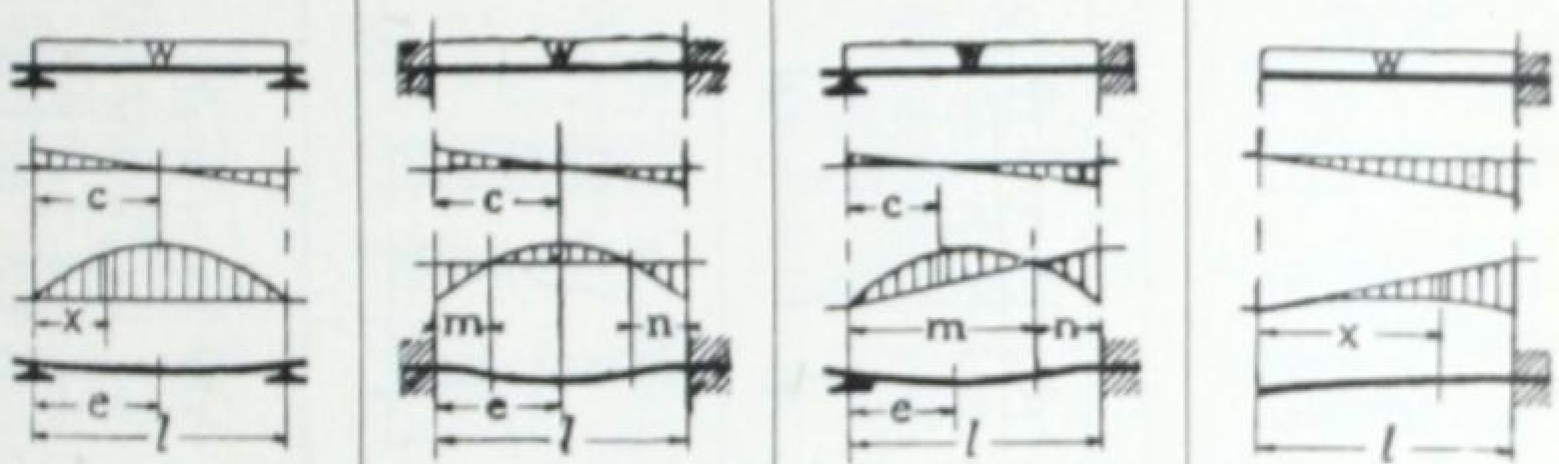
Section Modulus. z	Depth and Breadth. d	b	Weight per Foot.	Delivery.	Consisting of	Code Word.	Properties on page
Ins.^{3}	Ins.	Ins.					
176	15·7	11·8	101	a	BF Beam	BEWAF	18
179	17·2	11·7	96	a	,,	YOPUB	18
181	11	22	151	a*	2 BF Beams	BAHEL	17
185	15·7	11·8	110	a	BF Beam	BALUS	18
186	14·6	11·9	123	ai	,,	YOMIV	18
189	14·1	12	130	ai	,,	YOMAS	18
196	16·7	11·8	107	b	,,	BEWEG	18
199	15·4	11·9	124	bi	,,	YOMWO	18
200	16·7	11·8	112	b	,,	BALYT	18
200	18·3	11·7	102	c	,,	YORAF	19
206	13·2	12·2	158	ar	,,	YOBIK	17
210	11·8	23·6	162	a*	2 BF Beams	BAKEN	17
211	24	7·5	95	xs	Joist	AXIOM	172
218	17·7	11·8	113	a	BF Beam	BEWYL	18
220	15	12	145	ai	,,	YOMUX	18
222	16·1	11·9	132	ai	,,	YONAT	18
222	19·2	11·7	108	a	,,	YORBO	19
228	17·7	11·8	122	a	,,	BAMAP	18
229	14	12·2	166	ar	,,	YOBJE	17
235	15·7	12	147	bi	,,	YOMZY	18
240	18·7	11·8	119	c	,,	BEYFS	19
240	17·1	11·9	134	bi	,,	YONOY	18
244	18·7	11·8	124	c	,,	BAMIR	19
246	12·6	23·6	181	a	2 BF Beams	BAKIP	17
247	14·8	12·2	168	ar	BF Beam	YOBLO	18
253	21·2	11·7	113	c	,,	YORCE	19
260	16·5	12	155	ai	,,	YONEV	18
260	15·4	12·2	170	ar	,,	YOBUM	18
262	18	11·9	140	ai	,,	YONVE	18
264	19·7	11·8	125	a	,,	BEYHE	19
266	13·4	23·6	183	a	2 BF Beams	BAKMA	18
276	19·7	11·8	135	a	BF Beam	BAMOS	19
278	16·2	12·2	172	br	,,	YOBYN	18
280	19	11·9	141	ci	,,	YOOHR	19
281	17·5	12	157	bi	,,	YONUZ	18
291	16·9	12·1	172	ar	,,	YOCAJ	18
295	18·3	12	157	ai	,,	YONYO	18
299	23·1	11·7	124	b	,,	YOREJ	19
306	21·7	11·8	132	c	,,	BEYIJ	19
306	14·2	23·6	202	a*	2 BF Beams	BALEP	18
311	21·7	11·8	139	c	BF Beam	BAMUT	19
313	17·8	12·1	175	br	,,	YOCEK	18
316	19·3	12	160	ci	,,	YOOJS	19
325	20·1	11·9	158	ai	,,	YOOKT	19
328	15	23·6	204	b	2 BF Beams	BALRO	18
330	18·7	12	175	ar	BF Beam	YOCIL	18
331	25·1	11·7	128	b	,,	YORFU	19
352	23·6	11·8	141	b	,,	BEYKO	19
352	19·6	12	178	cr	,,	YOCYP	19
366	22	11·9	163	ci	,,	YOOLV	19
368	23·6	11·8	152	b	,,	BANRE	19
370	15·7	23·6	220	a	2 BF Beams	BALUS	18
371	20·5	12	180	ar	BF Beam	YODAK	19
388	27·1	11·7	141	b	,,	YORHI	19
400	16·7	23·6	224	b	2 BF Beams	BALYT	18
407	25·6	11·8	157	b	BF Beam	BAORY	19
414	23·9	11·9	171	bi	,,	YOONY	19
418	22·4	12	185	cr	,,	YODEL	19
424	29·1	11·7	145	b	,,	YORIL	19
431	31	14	155		Plate Girder	DOTIJ	250
433	42	12·4	120		,, ,,	DOWDA	250

Section Modulus. z	Depth and Breadth. d	b	Weight per Foot	Delivery.	Consisting of	Code Word.	Properties on page
Ins.^{3}	Ins.	Ins.					
447	31	14	168		Plate Girder	DOYPY	250
456	17·7	23·6	244	a	2 BF Beams	BAMAP	18
458	25·9	11·9	176	bi	BF Beam	YOOPZ	19
462	24·3	12	191	br	,,	YODNO	19
466	42	12·5	138		Plate Girder	DOZAJ	250
471	27·6	11·8	171	b	BF Beam	BAOSZ	19
475	31·2	14	167		Plate Girder	DREKA	250
488	18·7	23·6	248	c	2 BF Beams	BAMIR	19
491	31·2	14	180		Plate Girder	DREPS	250
493	31·2	11·7	159	b	BF Beam	YORKA	20
511	26·2	12	196	br	,,	YODUP	19
515	29·5	11·8	176	b	,,	BAVZE	19
517	48	12·4	127		Plate Girder	DRIDU	251
536	37	14	163		,,	DRIHA	250
552	19·7	23·6	270	a	2 BF Beams	BAMOS	19
556	28	11·9	201	br	BF Beam	YOECK	19
559	31·5	11·8	180	b	,,	BAWIC	20
560	37	14	178		Plate Girder	DUAFS	250
561	48	12·5	148		,,	DUAGH	251
567	33·1	11·7	174	c	BF Beam	YOROD	20
589	37·2	14	175		Plate Girder	DUBBU	250
607	30	11·9	207	br	BF Beam	YOEGN	19
608	32	14	203		Plate Girder	DUBIB	250
610	35·1	11·7	179	c	BF Beam	YORPY	20
613	37·2	14	190		Plate Girder	DUHEG	250
622	21·7	23·6	278	c	2 BF Beams	BAMUT	19
623	32	14	216		Plate Girder	DUHHU	250
637	33·5	11·8	196	c	BF Beam	BAWOD	20
645	43	14	171		Plate Girder	DUHLY	250
655	37·1	11·7	183	c	BF Beam	YORUJ	20
659	32	11·9	212	br	,,	YOELS	20
678	43	14	188		Plate Girder	DUIGH	250
686	35·4	11·8	201	c	BF Beam	BAWUF	20
697	32·5	14	227		Plate Girder	DUILB	250
707	43·2	14	182		,,	DUJAJ	250
707	33·8	11·9	218	cr	BF Beam	YOEMT	20
709	39·1	11·7	188	b	,,	YOSAN	20
712	32·5	14	239		Plate Girder	DUJDO	250
736	37·4	11·8	206	c	BF Beam	BAWZA	20
740	43·2	14	200		Plate Girder	DUJID	250
761	49	14	178		,,	DUKBA	251
761	35·7	11·9	223	cr	BF Beam	YOENV	20
772	38	14	226		Plate Girder	DUKGY	250
787	39·4	11·8	211	b	BF Beam	BAYEC	20
804	49	14	199		Plate Girder	DUNES	251
814	25·6	23·6	314	b	2 BF Beams	BAORY	19
816	37·7	11·9	229	cr	BF Beam	YOERZ	20
832	49·2	14	190		Plate Girder	DUOBE	251
873	39·7	11·9	234	b	BF Beam	YOEVD	20
875	49·2	14	211		Plate Girder	DUOHA	251
926	44	14	236		,,	DUXBI	250
942	27·6	23·6	342	b	2 BF Beams	BAOSZ	19
1019	44·5	14	242		Plate Girder	DUXNA	250
1030	29·5	23·6	352	b	2 BF Beams	BAVZE	19
1050	44·5	14	260		Plate Girder	DUYBO	250
1118	31·5	23·6	360	b	2 BF Beams	BAWIC	20
1188	50·5	14	250		Plate Girder	DWIBE	251
1274	33·5	23·6	392	c	2 BF Beams	BAWOD	20
1372	35·4	23·6	402	c	,,	BAWUF	20
1472	37·4	23·6	412	c	,,	BAWZA	20
1574	39·4	23·6	422	b	,,	BAYEC	20

FORMULÆ FOR

BENDING MOMENT, SHEAR AND DEFLECTION.

[For general explanation, see page 49.]

	Case 1.	Case 2.	Case 3.	Case 4.
ENDS.	Supported.	Fixed.	Supported and Fixed.	Free and Fixed.
LOAD.	Uniformly distributed.	Uniformly distributed.	Uniformly distributed.	Uniformly distributed.
LOAD. SHEAR. BENDING MOMENT. DEFLECTION.				
REACTIONS.	$\frac{W}{2}$ $\frac{W}{2}$	$\frac{W}{2}$ $\frac{W}{2}$	$\frac{3W}{8}$ $\frac{5W}{8}$	nil. W
MAXIMUM BENDING MOMENT.	$Wl \div 8$ *or* B	$-Wl \div 12$ *or* $-2B \div 3$	$-Wl \div 8$ ($-B$ at fixed end)	$-Wl \div 2$ *or* $-4B$
Point of Max. Bending Moment.	At centre.	At supports.	$\frac{5l}{8}$ from fixed end.	At fixed end.
MAXIMUM DEFLECTION.	$Wl^3 \div 76 \cdot 8$ EI *or* $fl^2 \div 4 \cdot 8$ dE *or* δ	$Wl^3 \div 384$ EI *or* $fl^2 \div 16$ dE *or* $\cdot 3\ \delta$	$Wl^3 \div 184 \cdot 5$ EI *or* $fl^2 \div 11 \cdot 53$ dE *or* $\cdot 416\ \delta$	$Wl^3 \div 8$ EI *or* $fl^2 \div 2$ dE *or* $2 \cdot 4\ \delta$
Point of Max. Deflection. *e*	At centre.	At centre.	$\cdot 4215l$ from left end.	At free end.
OTHER VALUES. B*l*	...	$Wl \div 12$	...	...
B*r*	...	$Wl \div 12$	$Wl \div 8$	$Wl \div 2$
B*x*	$Wx\,(l-x) \div 2l$	...	...	$Wx^2 \div 2l$
m, n	...	$\cdot 2114l$ $\cdot 2114l$	$\cdot 75l$ $\cdot 25l$	...

1. NOTATION.

W	=	load on beam.
l	=	length or span (to be measured from centres of bearings).
B	=	Maximum Bending Moment in Case 1 (distributed load, ends supported).
B*l*	=	Bending Moment at left end.
Br	=	„ „ „ right end.
Bx	=	„ „ „ distance x from left.
c	=	Distance from left of point of maximum positive bending moment.
e	=	„ „ „ „ „ deflection.
m, n	=	Points of contraflexure (zero bending moment), measured from ends.
f	=	Flexural stress—*e.g.*, 8 tons per square inch.
d	=	Depth of beam, or, if unsymmetrical, twice the distance from neutral axis to edge stressed to *f*.
I	=	Moment of Inertia (if not uniform throughout length, see page 49).
E	=	Elastic Modulus, say 13000 tons per square inch (but see page 49, § 7).
δ	=	Deflection at centre in Case 1 (distributed load, ends supported); its value is given on page 51 and in some of the tables of safe loads.

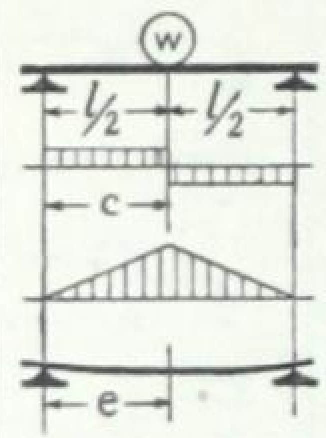
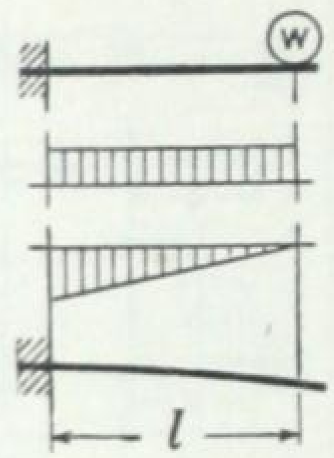
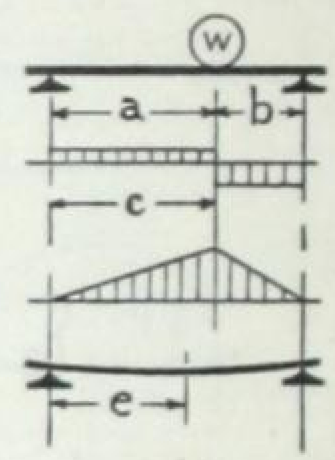
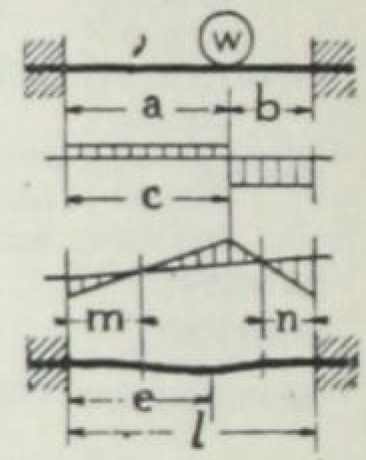
2. UNITS. In applying the formulæ, all quantities must, of course, be expressed in consistent units—say tons and inches.

[Continued on page 46]

FORMULÆ FOR

BENDING MOMENT, SHEAR AND DEFLECTION.—Continued.

[For general explanation, see page 49.]

	Case 5.	Case 6.	Case 7.	Case 8.
ENDS.	Supported.	Fixed and Free.	Supported.	Fixed.
LOAD.	Concentrated at centre.	Concentrated at end.	Concentrated at one point.	Concentrated at one point.
LOAD. SHEAR. BENDING MOMENT. DEFLECTION.				
REACTIONS left. right.	$\frac{W}{2}$ $\frac{W}{2}$	W nil.	$\frac{bW}{l}$ $\frac{aW}{l}$	$Wb^2(l+2a)\div l^3$ $Wa^2(l+2b)\div l^3$
MAXIMUM BENDING MOMENT.	$Wl\div 4$ *or* 2B	$-Wl$ *or* $-8B$	$Wab\div l$	$-Wa^2b\div l^2$
Point of Max. Bending Moment.	At centre.	At support.	Under load.	At near end.
MAXIMUM DEFLECTION.	$Wl^3\div 48\ EI$ *or* $fl^2\div 6\ dE$ *or* $\cdot 8\ \delta$	$Wl^3\div 3\ EI$ *or* $fl^2\div 1\cdot 5\ dE$ *or* $3\cdot 2\ \delta$	$\frac{Wab(l+b)\sqrt{3a(l+b)}}{27\ EIl}$	$\frac{2Wa^3b^2}{3\ (l+2a)^2\ EI}$
Point of Max. Deflection *e*	At centre.	At free end.	$\sqrt{3a\ (l+b)}\div 3$	$2al\div(l+2a)$
OTHER VALUES. B*l*	...	W*l*	...	$Wab^2\div l^2$
B*r*	...	...	...	$Wa^2b\div l^2$
B*x*	$Wx\div 2$	$W(l-x)$	$Wbx\div l$	...
m	...	...	...	$al\div(l+2a)$
n	...	...	...	$bl\div(l+2b)$

3. MAXIMUM BENDING MOMENT AND CHOICE OF SECTION. The above formulæ for maximum bending moment provide, in most cases, two ways of determining the required section of beam to carry a given load. Either (i) calculate the maximum bending moment (inch-tons)—by the first formula—and divide by the allowable working stress—*e.g.*, 8 tons per square inch. This gives the required section modulus; a suitable section can then be chosen from the table on page 43 (summary of sections in order of section modulus). Or, (ii) where the maximum bending moment is given in terms of B, multiply the actual load by the given factor of B. This gives the equivalent distributed load for a beam freely supported at both ends. A suitable section of beam can then be chosen from the tables of safe distributed loads.

N.B.—Care must be taken in the case of a short heavily-loaded beam that the shear stress is not excessive (see page 62).

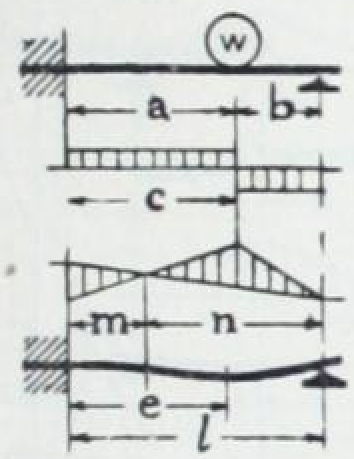
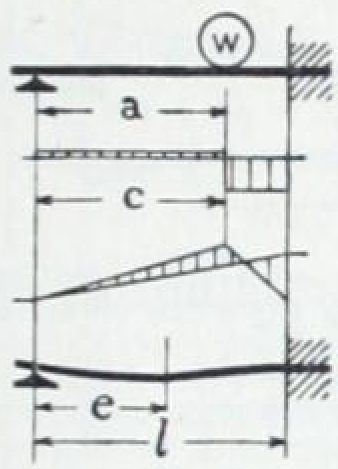
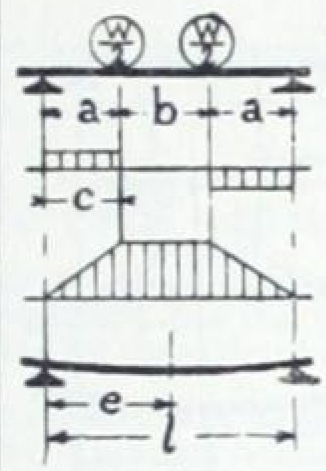
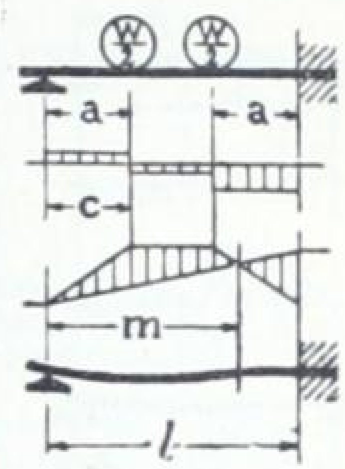
4. DEFLECTION. In most of the cases, two or more formulæ are given for calculating the maximum deflection. The values of δ are tabulated on page 51, and in some of the tables of safe loads. Accordingly, where a formula is given in terms of δ, this affords the easiest method of calculating the deflection.

In ordinary building construction, the deflection is usually limited to 1/360th of the span (1/325th in London, see B.S.S. 449, § 14).

5. WEIGHT OF GIRDER. In ordinary building construction, the weight of the girder itself is usually small in comparison with the superimposed load, but it must not be overlooked.

FORMULÆ FOR
BENDING MOMENT, SHEAR AND DEFLECTION.—Continued.

[For general explanation, see page 49.]

	Case 9.	Case 10.		Case 11.	Case 12.
ENDS.	Fixed & Supported.	Supported & Fixed.		Supported.	Supported & Fixed.
LOAD.	Concentrated at one point.	Concentrated $a=\frac{2}{3}l$	$a=\frac{3}{4}l$	Concentrated at two points.	Concentrated at two points.
LOAD. SHEAR. BENDING MOMENT. DEFLECTION.					
REACTIONS left. right.	$Wb(3l^2-b^2)\div 2l^3$ $Wa^2(2l+b)\div 2l^3$	$4W\div 27$ $23W\div 27$	$11W\div 128$ $117W\div 128$	$W\div 2$ $W\div 2$	$(2l^2-3la+3a^2)W\div 4l^2$ $(2l^2+3la-3a^2)W\div 4l^2$
MAXIMUM BENDING MOMENT.	$Wa^2b(2l+b)\div 2l^3$ (If a exceeds $\cdot 59l$)	$1\cdot 48B$	$1\cdot 31B$	$Wa\div 2$	$-3Wa\,(l-a)\div 4l$
Point of Max. Bending Moment.	Under load. (If a exceeds $\cdot 59l$)	At fixed support.		Between loads.	At fixed end.
MAXIMUM DEFLECTION.	$\dfrac{W\,(l+b)^3a^3b}{3\,(3l^2-b^2)^2\,EI}$ (If a exceeds $\cdot 59l$)	$\cdot 312\,\delta$	$\cdot 239\,\delta$	$\dfrac{Wa\,(3l^2-4a^2)}{48\,EI}$	...
Point of Max. Deflection. e	$2al\,(l+b)\div(3l^2-b^2)$	At centre.	$\cdot 522l$	At centre.	...
OTHER VALUES. Bl	$Wab\,(l+b)\div 2l^2$	...	...	...	...
Br	...	...	...	...	$3Wa\,(l-a)\div 4l$
Bx	...	...	...	...	...
m	$al\,(l+b)\div(3l^2-b^2)$	$18l\div 23$	$32l\div 39$	...	$2l^3\div(2l^2+3al-3a^2)$
n	$2l^3\div(3l^2-b^2)$	$5l\div 23$	$7l\div 39$	...	...

1. NOTATION.

W	=	load on beam.
l	=	length or span (to be measured from centres of bearings).
B	=	Maximum Bending Moment in Case 1 (distributed load, ends supported).
Bl	=	Bending Moment at left end.
Br	=	,, ,, ,, right end.
Bx	=	,, ,, ,, distance x from left.
c	=	Distance from left of point of maximum positive bending moment.
e	=	,, ,, ,, ,, ,, deflection.
m, n	=	Points of contraflexure (zero bending moment), measured from ends.
f	=	Flexural stress—*e.g.*, 8 tons per square inch.
d	=	Depth of beam, or, if unsymmetrical, twice the distance from neutral axis to edge stressed to f.
I	=	Moment of Inertia (if not uniform throughout length, see page 49).
E	=	Elastic Modulus, say 13000 tons per square inch (but see p. 49, § 7).
δ	=	Deflection at centre in Case 1 (distributed load, ends supported); its value is given on page 51 and in some of the tables of safe loads.

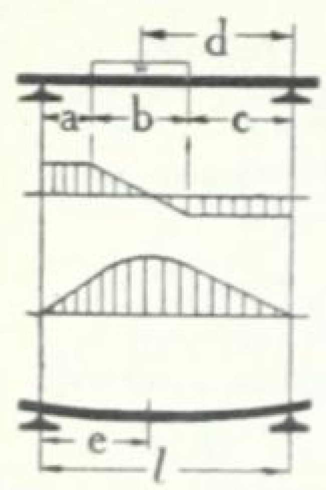
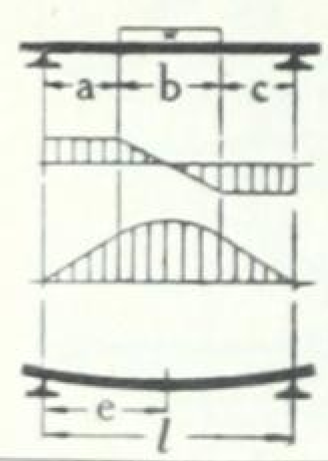
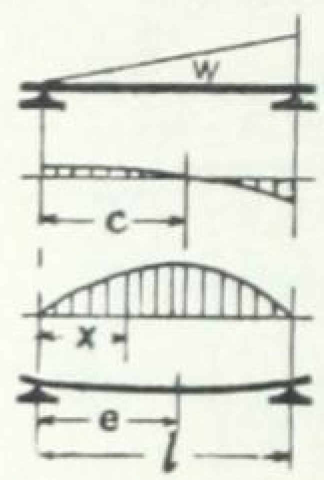
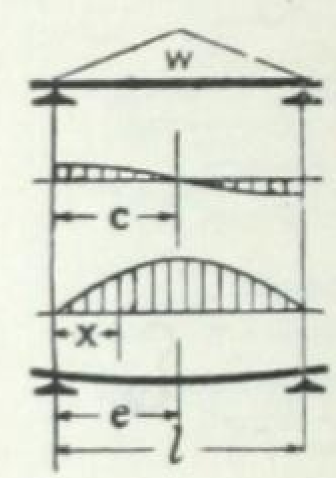
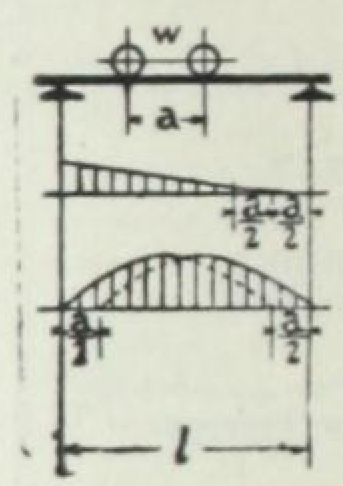
2. UNITS. In applying the formulæ, all quantities must, of course, be expressed in consistent units—say tons and inches.

[Continued on page 48.]

FORMULÆ FOR

BENDING MOMENT, SHEAR AND DEFLECTION.—Continued.

[For general explanation, see page 49.]

Case 13.	Case 13a.	Case 14.	Case 15.	Case 16.
Supported. Distributed over portion of span, as drawn.	Supported. Distributed, at centre of span.	Supported. Triangular, apex at end.	Supported. Triangular, apex at centre.	Supported. Rolling, concentrated at two points.
				
$\frac{W}{l}(c+\frac{1}{2}b)$	$\frac{Wb}{2}$	$W\div3$	$W\div2$	$W(2l-a)\div2l$
$\frac{W}{l}(a+\frac{1}{2}b)$	$\frac{Wb}{2}$	$2W\div3$	$W\div2$	$W(2l-a)\div2l$
$\frac{Wd}{l}\left(a+\frac{bd}{2l}\right)$	$\frac{W}{4}(l-\frac{1}{2}b)$	$Wl\div7\cdot8$ *or* $1\cdot025B$	$Wl\div6$ *or* $4B\div3$	$W(2l-a)^2\div16l$
$a+\frac{b\left(\frac{b}{2}+c\right)}{l}$	At centre.	$\cdot577l$	At centre.	$\frac{a}{4}$ from centre.
...		$Wl^3\div76\cdot6EI$ *or* $fl^2\div4\cdot91\ dE$ *or* $\cdot98\ \delta$	$Wl^3\div60\ EI$ *or* $fl^2\div5\ dE$ *or* $\cdot96\ \delta$	The bending moment is at a maximum when the load is at $^1/_4$ a from the centre of the span, as drawn above. The formulæ given for the end reaction are likewise for the worst case, viz., with one wheel over the adjacent support.
...		$\cdot519l$	At centre.	
...		... ... $Wx(l^2-x^2)\div3l^2$	... ... $Wx(3l^2-4x^2)\div6l^2$	

3. **MAXIMUM BENDING MOMENT AND CHOICE OF SECTION.** The above formulæ for maximum bending moment provide, in most cases, two ways of determining the required section of beam to carry a given load. Either (i) calculate the maximum bending moment (inch-tons)—by the first formula—and divide by the allowable working stress, *e.g.*, 8 tons per square inch. This gives the required section modulus; a suitable section can then be chosen from the table on page **43** (summary of sections in order of section modulus). Or, (ii) where the maximum bending moment is given in terms of B, multiply the actual load by the given factor of B. This gives the equivalent distributed load for a beam freely supported at both ends. A suitable section of beam can then be chosen from the tables of safe distributed loads.

N.B.—Care must be taken in the case of a short heavily-loaded beam that the shear stress is not excessive (see page 62).

4. **DEFLECTION.** In most of the cases, two or more formulæ are given for calculating the maximum deflection. The values of δ are tabulated on page 51, and in some of the tables of safe loads. Accordingly, where a formula is given in terms of δ, this affords the easiest method of calculating the deflection.

5. **WEIGHT OF GIRDER.** In ordinary building construction, the weight of the girder itself is usually small in comparison with the superimposed load, but it must not be overlooked.

BENDING MOMENT, SHEAR AND DEFLECTION.

GENERAL PRINCIPLES.

1. **CONDITION OF ENDS.** The end of a girder may be simply resting on a support, or it may be fixed thereto more or less rigidly, or it may be unsupported. When the stresses in a girder with ends simply supported are known, the stresses for other end conditions can be deduced.

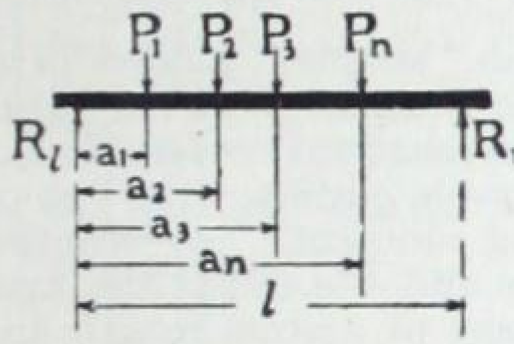


Fig. 1.

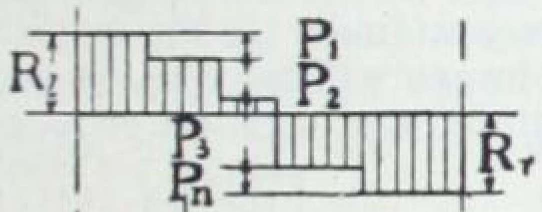


Fig. 2.

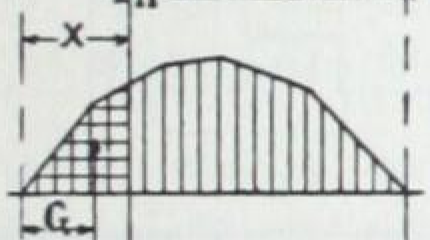


Fig. 3.

Fig. 4.

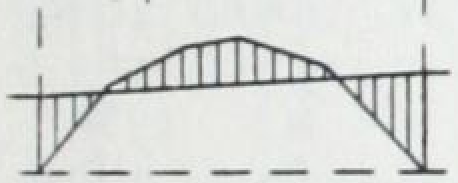


Fig. 5.

2. **LOADS.** These may be represented by P_1 etc., at distances a_1 etc., from the left (see Fig. 1).

3. **END REACTIONS.** These may be represented by R_l and R_r respectively.

Then $Rl + R_r = P_1 + P_2 + P_3$ etc.

Also $R_r \times l = P_1 a_1 + P_2 a_2$ etc.

$R \times l = P_1 (l - a_1) + P_2 (l - a_2)$ etc.

4. **SHEAR.** The force tending to shear vertically through the girder is greatest at the ends, there equalling the end reaction. The shear is decreased at every point of loading by the amount of the loads (see Fig. 2).

5. **BENDING MOMENT.** At any distance x from the left, the bending moment at that point equals the difference between the moment due to the reaction and the reverse moments due to the loads to the left of the point, the moment being the product of the Load or Reaction and its distance from the point.

6. **BENDING MOMENT DIAGRAM.** This is constructed by drawing a line proportional to the girder length, and setting up at right angles to it lines proportional to the bending moments at the various points of loading, and joining the extremities of the lines so drawn (Fig. 3). For a uniformly distributed load, the bounding line thus formed is a parabola.

7. **DEFLECTION.** If a tangent to the deflection curve be drawn at a point distant x (inches) from the left, and

δ = the vertical distance of this line from the support (see Fig. 4),
E = the Elastic Modulus of the material.
I = the Moment of Inertia of the girder taken as constant throughout its length

then δ EI = the area of the portion of the Bending Moment Diagram above the length x multiplied by the distance G of the centre of gravity of this area from the left reaction.

This equation gives a ready means of finding points on the deflection curve, when the Bending Moment Diagram is drawn.*

If the girder is not of uniform section so that the Moment of Inertia is not constant, the Bending Moment Diagram can be "corrected" by increasing the vertical ordinates in the ratio of maximum to actual Moment of Inertia, and then making I in the equation equal to the maximum Moment of Inertia.

The deflection so calculated is that due to flexural stress only. The shear stresses also cause deflection but only to a small extent in the relatively long spans where deflection is of importance.

Nevertheless, when the elastic modulus is calculated from deflection tests, a lower value is usually found than from tests in direct tension.

On these grounds it will sometimes be desirable to assign a reduced value to E for the purpose of calculating deflection; thus, E could be taken as 12000 tons instead of its actual value of about 13000 tons per square inch.

8. **OTHER END CONDITIONS.** If the ends are fixed, there will be upward bending moments at the supports; the Bending Moment Diagram can be constructed by first drawing as for supported ends, and then raising the base line to pass through the extremities of the lines representing the end bending moments (Fig. 5). This new base line will intersect the original bounding line at points where the bending moment is zero, known as the points of contraflexure.

In the formulæ on pp. 45 to 48 the end bending moments have been calculated by the principles of § 7, assuming that the tangent to the deflection curve at one support passes through the other, except, of course, for cantilevers, where the end bending moment is the product of the reaction and the distance of the centre of gravity of the load from the support. The bending moment at one end of the beam will increase the reaction at that end and diminish it at the other end by an amount equal to the quotient of the bending moment and the length of the beam.

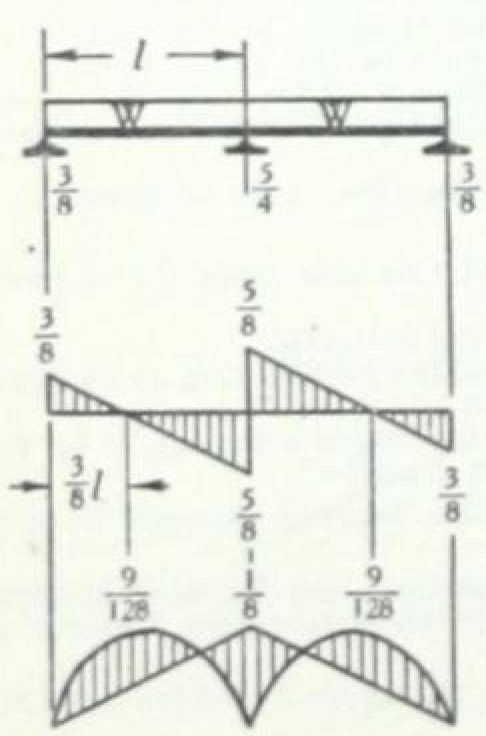
9. **CONTINUOUS BEAMS.** The end bending moments for continuous beams can be calculated by using the principles of § 7 and equating the two expressions for the inclination of the beam at a support, in terms of the spans on each side of the support, or by means of the coefficients given in the diagram on page 50.

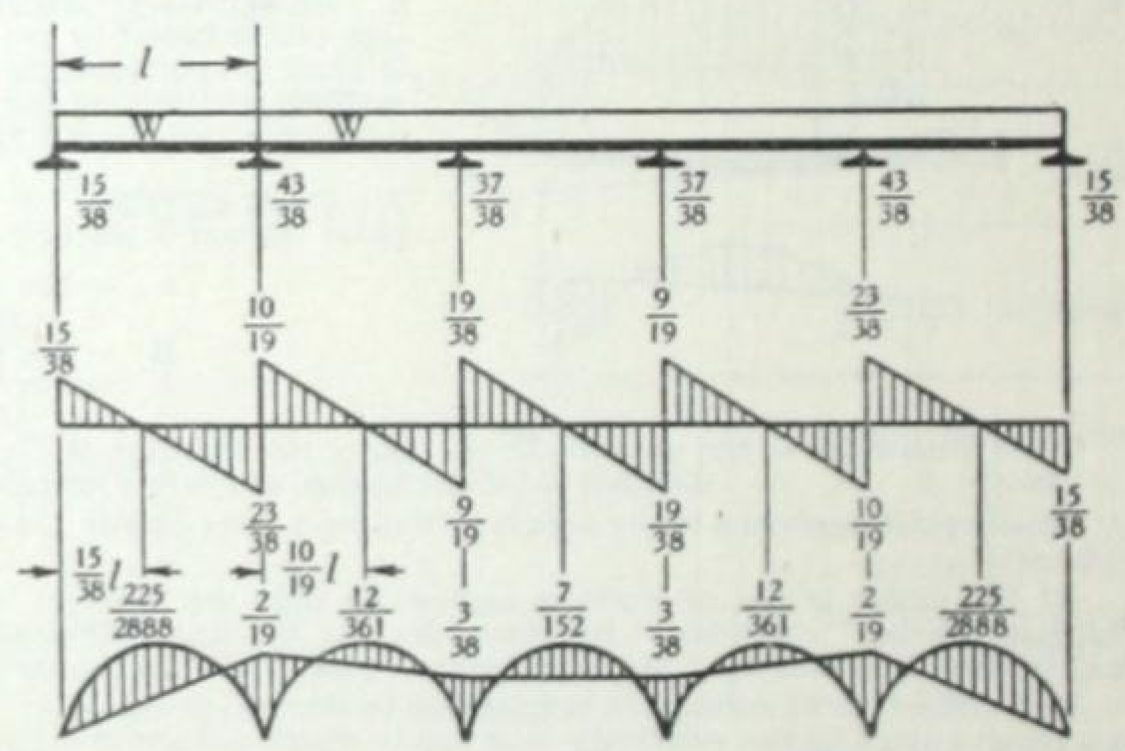
* The maximum deflection never differs greatly from that at the centre of the span. When the ends are restrained the central deflection calculated for a freely supported girder is reduced by the average of the end bending moments × span² ÷ 8 EI.

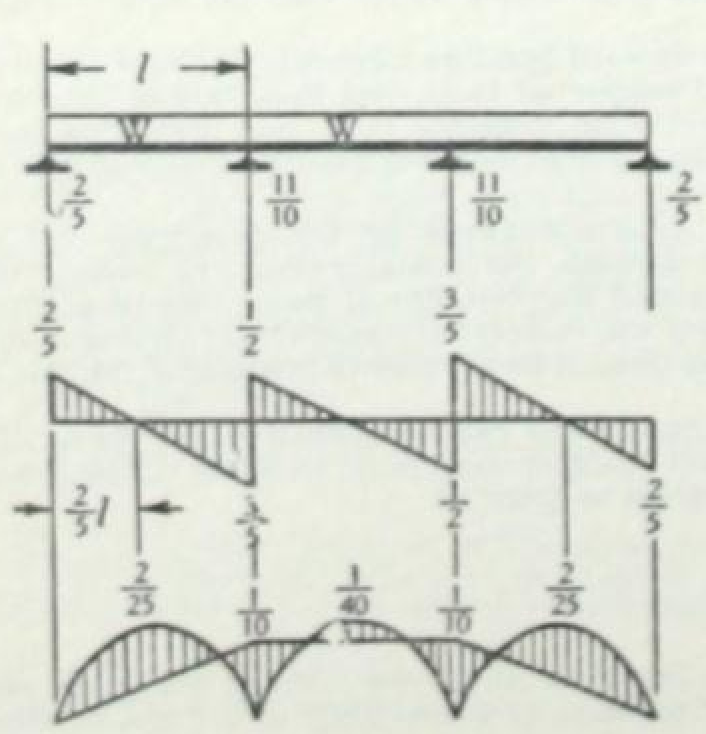
CONTINUOUS BEAMS

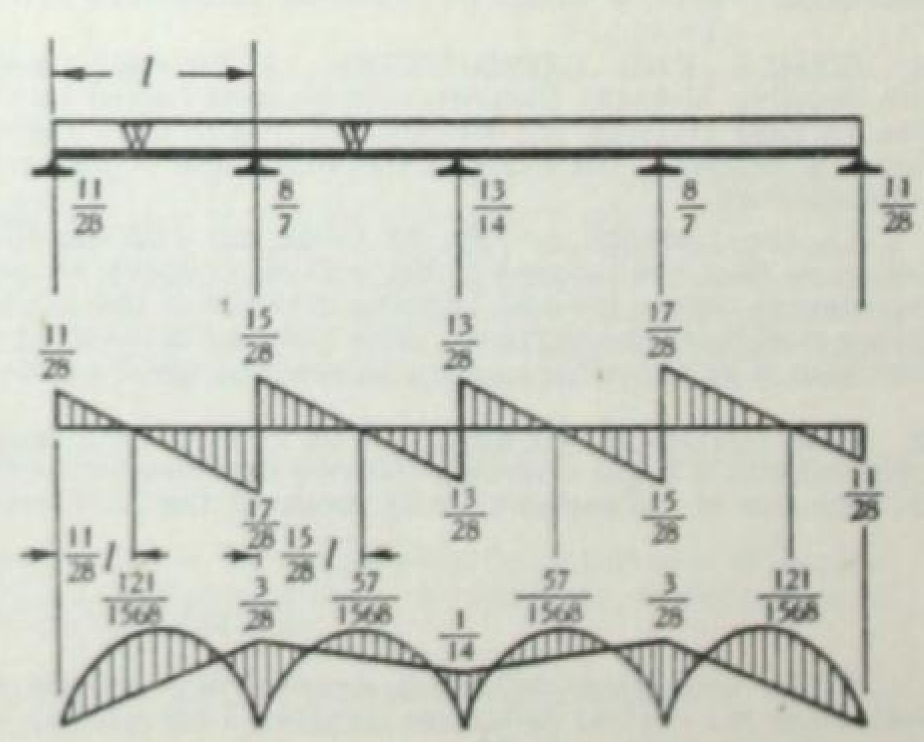
The coefficients shown in the following diagrams are based on the Theorem of Three Moments, and presuppose strict compliance with the following conditions :—(*a*) That the loads are equal and uniformly distributed over the spans. (*b*) That the effective spans are equal. (*c*) That the column caps are in the same plane. (*d*) That the beam is of uniform section. The specified Reaction and Shear coefficients are in terms of W ; the Moment coefficients are in terms of W*l*.

When weighing the relative advantages of continuous and " simple " girders in a given instance, the following points need to be considered : (1) The possibility of the actual load and distribution differing from those calculated. (2) The column reactions being unequal, some of the columns will have to be stronger and stiffer than for simple girders. (3) The position of maximum shear coincides with that of maximum bending moment. (4) Whether it is necessary to provide for expansion. (5) Heavy freight charges and site difficulties arise with long and heavy pieces : these will be avoided however if beams of normal length are made continuous by site-welding. (6) The foundations must be exceptionally good, so as to preclude unequal settlement. (7) In riveted construction, the columns will have to be broken at each storey. (8) The advantages are rigidity, reduction of girder section, and reduced costs of fabrication.









DEFLECTION OF GIRDERS.

LOAD UNIFORMLY DISTRIBUTED: 8 TONS STRESS.

Depth.	SPAN IN FEET.																					
	5	6	7	8	10	12	14	16	18	20	22	24	26	28	30	32	36	40	44	48	52	56
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
3	·15	·22	·30	·39	·62	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3¼	·14	·21	·28	·36	·57	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3½	·13	·19	·26	·34	·53	·76	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3¾	·12	·18	·24	·32	·49	·71	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	·12	·17	·23	·30	·46	·66	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4¼	·11	·16	·21	·28	·43	·63	·85	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4½	·10	·15	·20	·26	·41	·59	·80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4¾	·10	·14	·19	·25	·39	·56	·76	·99	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	·09	·13	·18	·24	·37	·53	·72	·95	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	·08	·11	·15	·20	·31	·44	·60	·79	·99	1·2	...	...	...	...	...	...	...	...	...	...	...	...
7	·07	·09	·13	·17	·26	·38	·52	·68	·85	1·1	1·3	1·5	...	...	...	...	...	...	...	...	...	...
8	·06	·08	·11	·15	·23	·33	·45	·59	·75	·92	1·1	1·3	1·6	...	...	...	...	...	...	...	...	...
9	·05	·07	·10	·13	·21	·30	·40	·53	·66	·82	·99	1·2	1·4	1·6	1·8	...	...	...	...	...	...	...
10	·05	·07	·09	·12	·18	·27	·36	·47	·60	·74	·89	1·1	1·2	1·4	1·7	1·9	...	...	...	...	...	...
11	·04	·06	·08	·11	·17	·24	·33	·43	·54	·67	·81	·97	1·1	1·3	1·5	1·7	2·2	...	...	...	...	...
12	·04	·06	·08	·10	·15	·22	·30	·39	·50	·62	·74	·89	1·0	1·2	1·4	1·6	2·0	2·5	...	...	...	...
13	·04	·05	·07	·09	·14	·20	·28	·36	·46	·57	·70	·82	·96	1·1	1·3	1·5	1·8	2·3	2·7	...	...	...
14	·03	·05	·06	·08	·13	·19	·26	·34	·43	·53	·64	·76	·89	1·0	1·2	1·4	1·7	2·1	2·6	3·0	...	...
15	·03	·04	·06	·08	·12	·18	·24	·32	·40	·49	·60	·71	·83	·96	1·1	1·3	1·6	2·0	2·4	2·8	...	...
16	·03	·04	·06	·07	·12	·17	·23	·30	·37	·46	·56	·66	·78	·90	1·0	1·2	1·5	1·8	2·2	2·7	3·1	...
18	·03	·04	·05	·07	·10	·15	·20	·26	·33	·41	·50	·59	·69	·80	·92	1·1	1·3	1·6	2·0	2·4	2·8	3·2
20	·02	·03	·05	·06	·09	·13	·18	·24	·30	·37	·45	·53	·62	·72	·83	·95	1·2	1·5	1·8	2·1	2·5	2·9
22	·02	·03	·04	·05	·08	·12	·16	·21	·27	·34	·41	·48	·57	·66	·76	·86	1·1	1·3	1·6	1·9	2·3	2·6
24	·02	·03	·04	·05	·08	·11	·15	·20	·25	·31	·37	·44	·52	·60	·69	·79	1·0	1·2	1·5	1·8	2·1	2·4
26	·02	·03	·03	·05	·07	·10	·14	·18	·23	·28	·34	·41	·48	·56	·64	·73	·92	1·1	1·4	1·6	1·9	2·2
28	·02	·02	·03	·04	·07	·09	·13	·17	·21	·26	·32	·38	·45	·52	·59	·68	·85	1·1	1·3	1·5	1·8	2·1
30	·02	·02	·03	·04	·06	·09	·12	·16	·20	·25	·30	·35	·42	·48	·55	·63	·80	·98	1·2	1·4	1·7	1·9
32	·01	·02	·03	·04	·06	·08	·11	·15	·19	·23	·28	·33	·39	·45	·52	·59	·75	·92	1·1	1·3	1·6	1·8
34	·01	·02	·03	·03	·05	·08	·11	·14	·18	·22	·26	·31	·37	·43	·49	·56	·70	·87	1·1	1·3	1·5	1·7
36	·01	·02	·03	·03	·05	·07	·10	·13	·17	·21	·25	·30	·35	·40	·46	·53	·66	·82	·99	1·2	1·4	1·6

The table above is applicable to all symmetrical sections and is valid, therefore, for Rolled Steel Joists, Channels, and Riveted Girders of uniform depth and plated on top and bottom flanges alike. For formula, see page 45, Case 1.

ZIG-ZAG LINE. This marks the present customary limit, for floor beams (fully stressed), of 24 times the depth. The 1937 L.C.C. By-laws and B.S.S. 449 allow 16 times the depth for high tensile steel; and 32 times the depth for filler joists embedded in concrete, taking the depth from the bottom flange to the upper face of the concrete slab.

NOTES ON GIRDERS.

1. LATERAL STABILITY.

If the top flange of a girder is not supported sideways at intervals of at most 20 times the flange width, the working stress should be reduced, by a percentage equal to twice l/b—20, where l/b is the ratio of span to flange width, thus :—

For ratio l/b	=	25	30	35	40	45	50
Reduction	=	10%	20%	30%	40%	50%	60%

These percentages coincide with the provisions of the London County Council By-Laws (and B.S.S. 449, § 10) ; see page 281.

For Broad Flange Beams 12″ × 12″ and upwards, all of which have flanges 11·8″, the value of l/b is approximately the same as the span in *feet.*

2. ECCENTRIC LOADS.

When an eccentric load tends to cause a girder to twist, the bending moment (load multiplied by eccentricity) may be considered as setting up a lateral thrust in opposite directions on the top and bottom flanges, equalling the bending moment divided by the girder depth.

These side thrusts will set up horizontal bending moments in each flange, and the stresses due to these must be added to those due to the vertical bending moment produced by the load considered as centric.

3. LIVE LOADS IN BUILDINGS.

In building construction, the live load on a floor is usually treated as equivalent to an assumed dead or stationary load, distributed uniformly over the floor area.

The London County Council By-Laws (and B.S.S. 449) also require floors to be capable of supporting appropriate concentrated loads—see page 280, § 8a and special table on page 228.

For floors carrying machinery with heavy moving parts, special calculation is necessary.

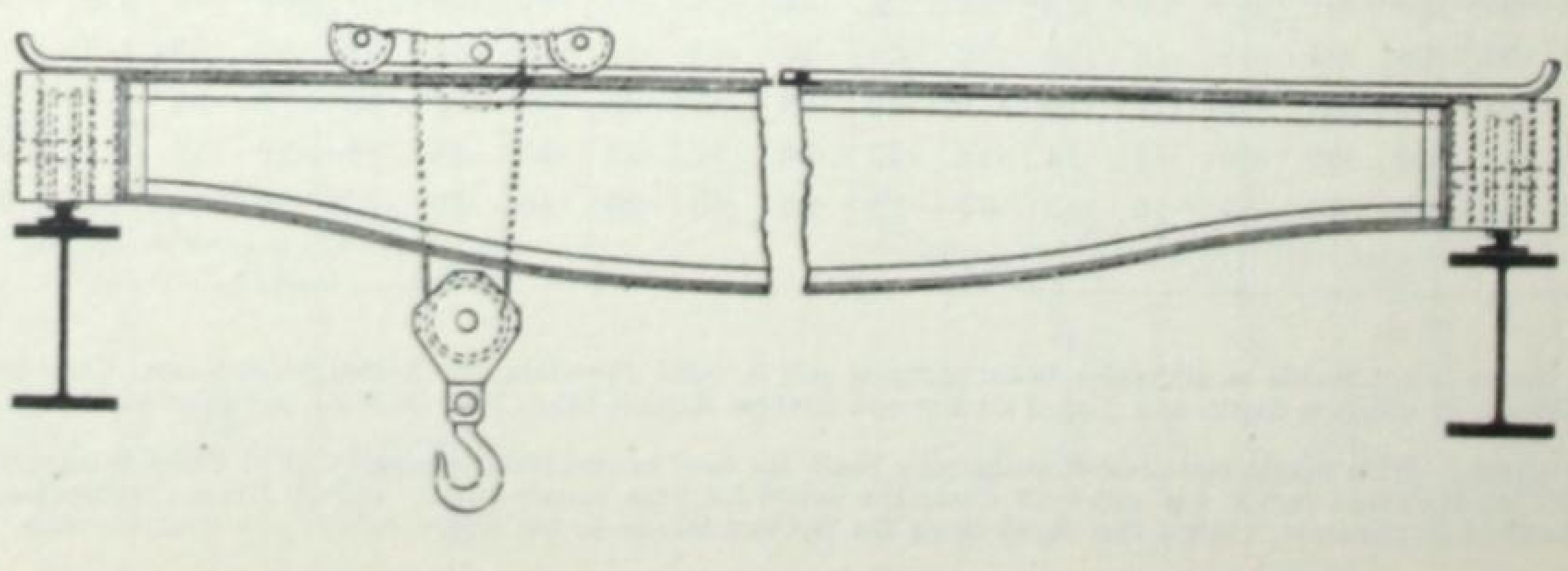
4. TEMPERATURE LENGTH CHANGES.

In Britain, the maximum range of temperature in structural work exposed to the weather is about 100° F. In buildings, however, the range will rarely be so great.

For a change in temperature of 100° F. the change in length of structural steel will be 1/8″ in a length of 15¾ feet approx.

In long stretches of steelwork, expansion must be provided for by means of clearances and slotted holes.

5. CRANE GANTRY GIRDERS.



NOTES ON GIRDERS.—Continued.

5. CRANE GANTRY GIRDERS.—Continued.

The effect of applying a load suddenly is to double the stress it would produce as a stationary load.

In the case of moving cranes, the maximum flexural stresses in the gantry are reached gradually, and the maximum load on the end carriage rarely occurs when the crane is travelling. It is now considered sufficient to add 20% of the wheel loads, as the allowance for impact, or 25% for cranes lifting 5 tons and upwards. Some makers add only 10%.

The position of maximum shear stress is reached when, with the leading wheel of the end carriage on the gantry, the rear wheel passes on to it from the next span; as the load on this wheel is applied suddenly, it must be added to the shear due to both wheels to obtain the equivalent stationary shear stress.

The effects of cross travel and cross drag should be considered in conjunction with the most unfavourable conditions of loading. They may be taken as equivalent to a static load P applied horizontally to the top flanges of the two gantry girders, where P = 15% of the combined weight of the load and crab.

The horizontal pressure P may be assumed to be distributed equally between the top flanges of the two girders, unless the frictional grip F (taken as 20% of the load on the end carriage wheels) between the rail and the more lightly loaded wheels is less than P ÷ 2. In such a case the girders must be proportioned to withstand a side thrust of P — F.

When the unsupported length of girder is more than 20 times the flange width, the working stress must be reduced, see § 1 on previous page, or the top flange strengthened.

This is not usually necessary in the case of B.F. Beams, but when the compression flange of a deep B.F. Beam is found to require lateral stiffening, a 15″ × 4″ channel riveted web uppermost to the top flange of the beam (Fig. 1) is a very efficient arrangement.

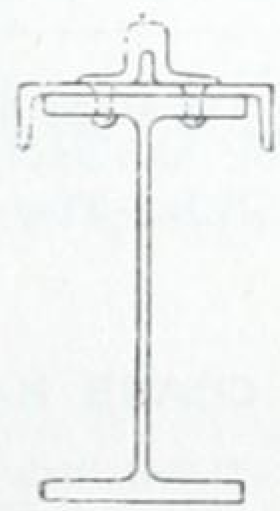


Fig. 1.

The inertia effect due to the sudden stopping of a rapidly moving crane should be taken as equivalent to a stationary thrust along the crane girder equal to 20% of the load on the rail. This thrust must, of course, be resisted by the stanchions carrying the crane girder.

The advantages of B.F. Beams as girders under crane runways are:

(i) The useful range of sizes up to 40″ deep, with 12″ flanges.

(ii) Lateral stiffness increases in proportion to the *square* of the flange width, so that the 1·26″ flanges of a 24″ × 12″ B.F. Beam, for example, are over three times as strong laterally as the 1″ flanges of a standard 24″ × 7½″ R.S. Joist.

(iii) They afford a flat surface, free from rivets, for bolting on the crane rails. Compare Figs. 2 and 3.

The average weights and dimensions of cranes are tabulated on page 54.

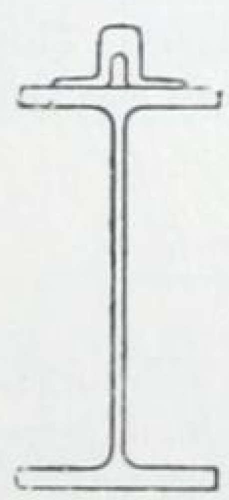


Fig. 2.

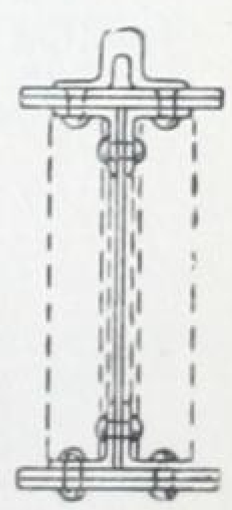


Fig. 3.

6. APPROXIMATE WEIGHTS AND DIMENSIONS OF CRANES.

Lift.	Maximum Weight on end Carriage. L = Span of Crane in Feet.	Weight of Crab.	Headroom from Top of Rail.	End Clearance from Centre of Rail.	Centres of End Carriage Wheels.	Overall Length of End Carriage.
Tons.	Tons.	Tons.				
2	2·8 + ·080 L	0·85	6′ 0″	8″	8′ 6″	11′ 8″
5	7·3 + ·082 L	1·85	6′ 2″	9″	8′ 6″	13′ 1″
7½	9·3 + ·115 L	2·75	6′ 10½″	9¼″	10′ 0″	13′ 4″
10	11·7 + ·127 L	3·20	7′ 4″	9¼″	10′ 0″	13′ 4″
15	17·5 + ·125 L	3·50	7′ 0″	9¾″	10′ 0″	14′ 4″
20	23·6 + ·130 L	4·50	7′ 3″	10¼″	10′ 0″	14′ 9″
25	28·4 + ·165 L	5·50	7′ 4½″	10¾″	12′ 0″	15′ 0″
30	$20{\cdot}0 + 3{\cdot}2\sqrt{L}$	6·50	8′ 0″	11¼″	12′ 0″	15′ 6″
40	$28{\cdot}0 + 3{\cdot}8\sqrt{L}$	9·00	9′ 0″	11¾″	13′ 0″	17′ 0″
50	$35{\cdot}0 + 4{\cdot}5\sqrt{L}$	11·00	9′ 9″	11¾″	13′ 0″	17′ 6″
60	$40{\cdot}0 + 5{\cdot}4\sqrt{L}$	13·00	10′ 0″	12¼″	13′ 0″	18′ 0″

The above figures are based on the tables given in Sir William Arrol & Co.'s " Handbook," 1920; and apply to machine shops and similar buildings.

N.B.—The centres of end carriage wheels should not be less than one-sixth of the span.

7. CRANE RAILS.

The British Standard sizes of Bridge Rails weigh 14, 16, 18, 20, 24, 56 and 70 lb. per yard respectively. The two heaviest sizes, shewn in Figs. 4 and 5 below, are readily obtainable in small lots.

For yet heavier work the Continental solid type shewn in Fig. 6 and accompanying table is often employed. This pattern is not stocked and may be found to be unobtainable if ordered in lots of less than 40 to 50 tons of a size.

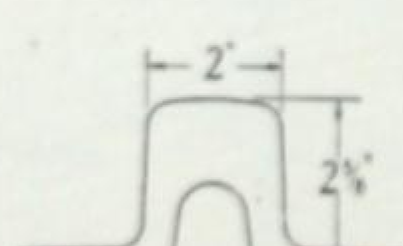


Fig. 4. 56 lbs per yard

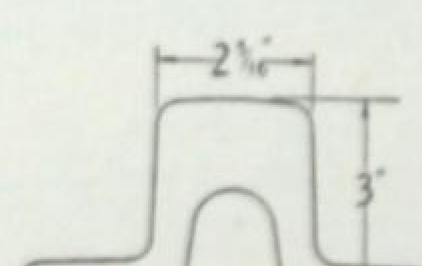


Fig. 5 70 lbs per yard

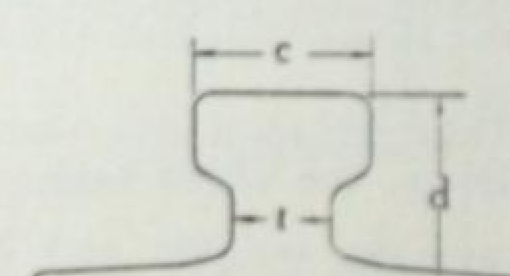


Fig. 6

SIZES AND PROPERTIES OF SOLID CRANE RAILS (Fig. 6).

Section No.	Size.				Weight per yd.	Moment of Inertia.	Section Modulus.	Area.
	b	d	c	t				
	Ins.	Ins.	Ins.	Ins.	Lb.	$Ins.^4$	$Ins.^3$	$Ins.^2$
1	4·92	2·16	1·77	·94	45·4	2·26	1·78	4·45
2	5·91	2·56	2·16	1·22	64·9	4·33	2·88	6·35
3	6·89	2·95	2·56	1·50	88·3	7·89	4·52	8·65
4	7·87	3·35	2·95	1·77	115	12·57	6·41	11·3
5	7·87	3·35	3·54	1·97	125	14·82	7·65	12·3
6	7·87	3·74	3·94	2·36	151	21·65	10·6	14·8
7	8·66	4·13	4·72	2·83	205	34·24	15·0	20·1

8. RAILWAY BRIDGE GIRDERS.

For comparatively short bridge spans, the effect of impact from all causes (unbalanced driving wheels, irregularity of track, suddenness of application of load, etc.) may be taken as doubling the actual train load.

The overturning moment due to wind pressure on the train increases the vertical load on the leeward girder and decreases it on the windward. The wind load (say 30 lb. per square foot of exposed vertical surface) may be taken as 3 cwts. per foot run acting as a horizontal load 7′ 6″ above the rail.

The effect of sudden application of the brakes may be taken as equivalent to a suddenly applied load equalling 20% of the weight of the train, acting along the rails and resisted at the end bearings.

When the rails are on a curve, an outward horizontal thrust is set up by the moving train.

If W = weight of train,
v = speed of train in miles per hour,
r = radius of curvature in feet,

the side thrust $= Wv^2 \div 15\, r$ and may be assumed to act in a plane 5 feet above the rail level. This thrust will have a similar effect to the wind load and must be allowed for in conjunction with it.

Broad Flange Beams, Grey Process, especially sections 24″ × 12″ to 40″ × 12″, have been employed extensively as main girders in railway bridges of spans up to 40 feet or so; the smaller sections are used as rail bearers and cross girders in larger spans. The saving in weight and cost of workmanship as compared with plate and angle girders is considerable, and the cost of maintenance is also reduced owing to the diminished liability to corrosion of a solid steel beam.

9. ROAD BRIDGES.

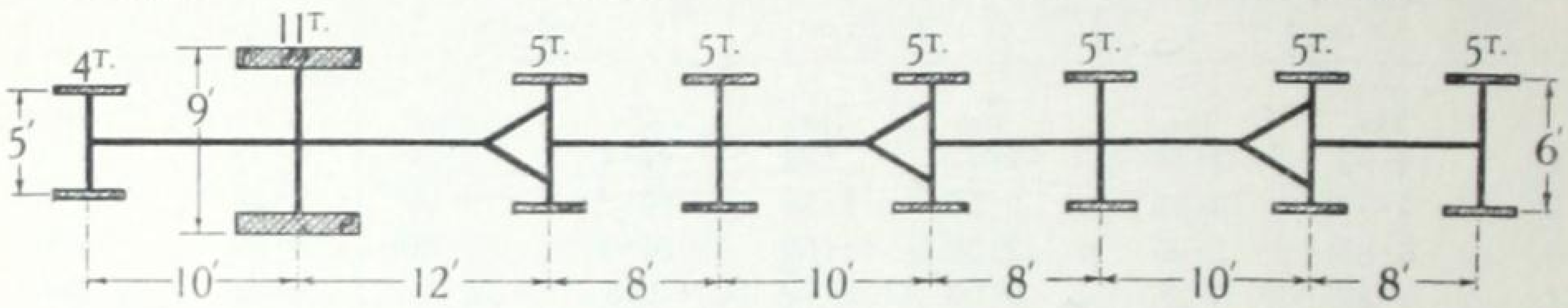
In road bridges the unevenness of the surface greatly intensifies the stresses set up by vehicles, and the equivalent stationary load should be taken as double the moving load.

Ordinary traffic on portions of the bridge not occupied by the wheel loads may be taken as equivalent to a stationary load of 1 cwt. per foot super, increased to $1\frac{1}{4}$ cwt. for a distance of 3 feet out from each parapet.

The effect of wind pressure on the main and cross girders must also be considered, but the bridge floor itself will usually constitute a more than adequate wind bracing.

NOTES ON GIRDERS.—Continued.

In Great Britain, the Ministry of Transport requires Highway Bridges to be capable of supporting Standard Trains as per annexed diagram—one to every 75 feet of span.



The wheel loads shewn in the diagram correspond to those of a 20-ton traction engine drawing three trailers loaded to 13 tons each, plus 50% for impact. The engine is assumed to be 9 feet wide overall and to occupy 10 feet of roadway. This loading may be taken (Circular of September, 1931) as equivalent to the following :—

(i) A distributed load per square foot, varying according to the span as per table below. The tabulated loads include the required allowances for impact.

(ii) In addition, a concentrated (knife-edge) load of 2700 lb. per foot of width, being the difference in weight between the maximum axle load (22 tons nominal) and the remaining axles (10 tons nominal).

EQUIVALENT DISTRIBUTED LOADS.
Per Square Foot.

Span.	Load.	Span.	Load.	Span.	Load.	Span.	Load.	Span.	Load.	Span.	Load.
Ft.	Lb.	Ft.	Lb.	Ft.	Lb.	Ft.	Lb.	Ft.	Lb.	Ft.	Lb.
3	2420	7	625	100	208	500	140	1300	97	2100	76
3½	2020	7½	525	150	192	600	132	1400	94	2200	74
4	1700	8	444	200	180	700	125	1500	90	2300	73
4½	1445	8½	374	250	170	800	119	1600	88	2400	72
5	1225	9	314	300	163	900	114	1700	85	2500	70
5½	1033	9½	265	350	156	1000	108	1800	82	...	...
6	872	10	220	400	150	1100	104	1900	79	...	...
6½	735	75	220	450	145	1200	100	2000	77	...	...

These live loads must be deemed to be applied in the most unfavourable manner, namely :—

(i) For Bending Moment, the knife-edge load will be taken at the centre of the span.

(ii) For Shear, it will be taken at a support.

(iii) For Shear at an intermediate point, the concentrated load will be taken as applied at that point ; and the tabular distributed load will be taken as applied only between that point and the farther support.

In transverse members the knife-edge load is taken as 2700 lb. per foot run of the *beam*. In slabs, it is deemed applied across the centre of the span of the slab, irrespective of the direction of the slab.

If members, whether transverse or longitudinal, are less than 5 feet apart, they must be calculated for the live load applicable to beams at 5 feet centres.

In continuous flooring, excluding the end panels and first intermediate support, the bending moment may be taken as 4/5ths of that for free ends.

The safe compressive stress of concrete may be taken as 5A + 300 lb. per square inch, where A is the weight (lb.) of Portland Cement to 2 cubic feet of fine and 4 cubic feet of course aggregate ; this is one-third of the crushing strength to be shewn on test at 28 days with ordinary, or at 7 days with Rapid Hardening Cement.

10. GIRDERS CARRYING BRICK WALLS.

Usual British practice is to design the girder to carry a uniformly distributed load equal to the weight of the brickwork enclosed in an equilateral triangle with the span as base, though after the brickwork is set, the actual triangular load on the girder will have a height of only about 1/3rd of the span.

If floor or other loads come on the brickwork immediately above the opening they must, of course, be added to the weight of the brickwork.

The deflection in girders carrying brickwork should be limited to 1/500th of the span

11. END BEARINGS FOR GIRDERS.

The following pressures are ordinary safe allowances for walls or piers of moderate height:—

Material.	Tons per sq. foot.	Material.	Tons per sq. foot.
Granite	30	Blue Brick in cement ...	12
Portland and Compact Limestone	20	Hard Brick in cement ...	8
Hard York Stone	15	Ordinary Brick in cement ...	5
Ordinary Limestone	6	Ordinary Brick in lime mortar	4

For purposes of calculation it is assumed that the pressure is uniformly distributed over the contact surface though, actually, the deflection of the girder tends to concentrate the pressure on the edge, which should accordingly be chamfered.

The London County Council and British Standard Specification 449, base the allowable pressures on the ascertained crushing strength of the bricks or stone used. For bricks in cement, the allowable pressures range from 4 to 40 tons per square foot, according to the quality of the bricks and composition of the mortar. These pressures have to be reduced for walls or piers of which the height is more than six times the least dimension : thus, for eight times, reduce by 20% ; for ten times, reduce by 40% ; for twelve times, reduce by 60% (see page 39 of B.S.S. 449, extracts on page 285 hereof).

12. BEARING PLATES AND STONE TEMPLATES.

The area of the plate is determined by the allowable pressure on the material below (see § 11 above). The thickness may be calculated as follows :—

If a = lateral projection of the plate (inches),
t = required thickness (inches),
P = allowable pressure (tons per square foot) on bearing material,
f = allowable flexural stress (lb. per square inch) in the plate,

then the total upwad load on a 1″ strip of the projecting area will be $P \times a \times 2240 \div 144$ lb., setting up a bending moment in the plate of $P \times a^2 \times 1120 \div 144$ inch-pounds, which equals

Cleats. &c.
Column Loads.
Column Notes.
Caps, Bases.
Poles, Piles.
I
[●
<T
Rivets, Bolts.
Roofs, Concrete
Welding.
Plates, Inertia.
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

the resistance moment of the plate, viz., $f \times t^2 \div 6$.

$$\therefore t = 7a \times \sqrt{P \div f} \text{ approximately.}$$

The values of f may be taken as follows :—

First-class	York Stone	80	lb. per square inch.
,, ,,	Limestone	150	,, ,, ,, ,,
,, ,,	Granite	180	,, ,, ,, ,,
Steel ...	...	22,400	,, ,, ,, ,,

13. STEEL BEAMS AS TEMPLATES.

Rolled steel beams are sometimes used to distribute a heavy load over brickwork. B.F. Beams, Grey Process, are useful for this purpose, and a table is given on page 63 shewing the required sections and lengths for various loads. The mode of calculation is as follows :—

(i) The area of contact surface must be such as to limit the pressure per square foot on the brickwork to a safe figure—*e.g.*, 10 tons per square foot on hard bricks laid in cement.

(ii) The flexural, shear and transverse stresses in the template beam are calculated on the assumption that the template beam acts as a pair of cantilevers, each bearing a distributed load equal to half the total load.

(iii) The principal compressive stress resulting from the combined flexural, shear and transverse stresses must not exceed the safe principal compressive stress, as tabulated for B.F. Beams on page 38, and for ordinary steel joists on page 137. This is the factor determining the sizes and lengths tabulated on page 63 ; the flexural, shear and transverse stresses, separately considered, are well below the allowable limits.

(iv) If the load on the template beam were actually concentrated at a point, as in Fig. 1, the web of the beam would be liable to buckle as a column by direct pressure. But in practice,

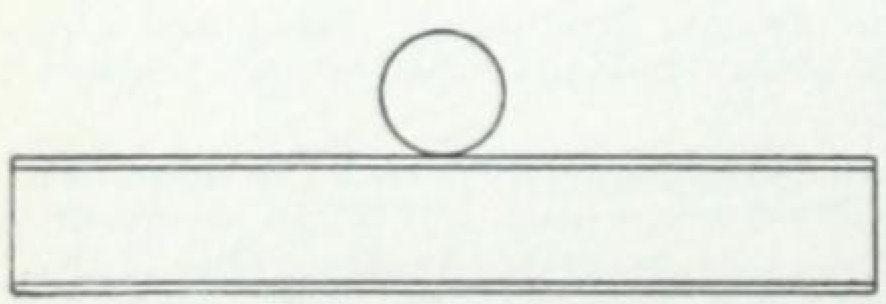


Fig. 1.

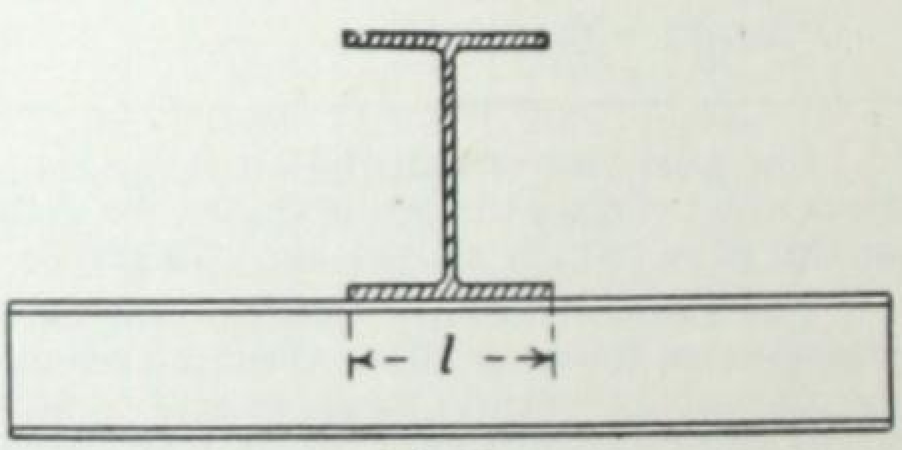


Fig. 2.

the load on the template beam will almost always be distributed (as in Fig. 2) over a length "l" of the template sufficient to keep the pressure within safe limits.

In exceptional cases the sufficiency of the web can be investigated as in § 4, page 62.

14. STIFFENERS.

When stiffeners are employed, the concentrated load or end reaction, as the case may be, must be regarded as divided between the stiffeners and the web in proportion to their respective capacities.

Two angles, one on each side of the web, make the most effective stiffeners, and as the radius of gyration of the pair about the centre of the web will be fairly large, except for deep plate girders, the required area of the angles may be safely taken as 1 square inch per

NOTES ON GIRDERS.—Continued.

$5\frac{1}{2}$ tons of load without further investigation. The angles should be ground to fit between the flanges at top and bottom and be connected to the web by a sufficient number of rivets at a pitch not greater than 5″, to take up whatever proportion of the load they are assumed to carry. This proportion, in the case of Rolled Steel Beams, may be safely taken as 50% (of the reaction or load, as the case may be).

For Plate Girders it is better to regard the capacity of the web for resisting compression due to direct load as nil, so that stiffeners should be put at all points of concentrated loads and reactions. In this case, besides stiffening the web against buckling and transmitting the load or reaction to the web, they act as connections between the top and bottom flanges, stiffening the compression flange against local buckling and lateral flexure.

The spacing and size of the stiffeners are usually determined by various practical considerations, but generally the centres of the stiffeners should not be greater than the depth of the girder. See also page 284 (" B.S.S. 449 ").

The webs of B.F. Beams, Grey Process, are designed of sufficient thickness to avoid the need of stiffeners under usual conditions of loading. Stiffeners on plain rolled steel beams are relatively costly, since to fit them usually entails extra handling and carriage from mills to the constructional yard.

15. FLOOR GIRDERS IN BUILDINGS.

Broad Flange Beams are employed with advantage as floor girders in buildings, in such cases as the following :—

(*a*) If the span and load are beyond the capacity of ordinary steel joists.

(*b*) In cases where the depth of an ordinary joist would be so great as to necessitate riveting angle shelves to the web to carry the flooring, a considerable saving in cost can be effected by substituting Broad Flange Beams, which usually enables such angle shelves to be dispensed with.

(*c*) In some cases, the extra weight of steel involved in using a shallow girder is more than compensated for by the saving in cost resulting from a reduction in the thickness of the floors and consequent reduction in the total height of the building.

(*d*) In some types of fire-proof flooring, the ample bearing surface afforded by wide flanged beams is essential ; in such cases, the fact of the flanges being without taper is an additional advantage.

Fig. 1 shews a typical use of Broad Flange Beams in conjunction with ordinary round steel reinforcing bars.

Fig. 2 shews a similar arrangement, using an ordinary rolled steel joist of the same carrying power ; the superior bearing afforded by the Broad Flange Beam in Fig. 1 is obvious.

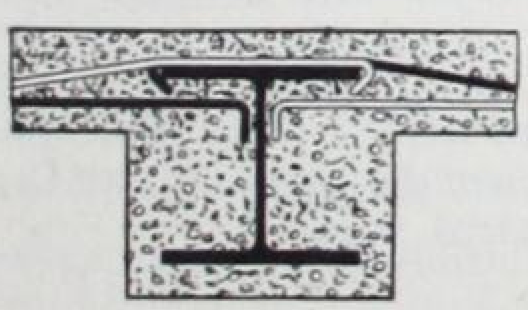


Fig. 1.

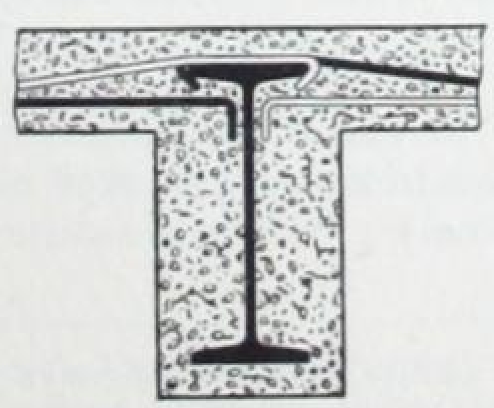


Fig. 2.

STRESSES IN GIRDERS.

1 FLEXURAL STRESS.

The various tables of safe loads are for beams freely supported at both ends and bearing a uniformly distributed load. The diagrams and formulæ on pages 45 to 49 provide a ready means of calculating the safe loads and deflections for many other conditions of ends and loading.

The simplest means of providing for irregular loading is to ascertain, by calculation or graphically, the maximum bending moment and shear. The former divided by the allowable flexural stress—*e.g.*, 8 tons per square inch—is the required section modulus, as given in the tables of properties of the various sections of beams, channels, etc.

2. SHEAR STRESSES.

The vertical and horizontal shear stresses are equal at any point in a cross section ; they decrease from a maximum at the neutral axis to zero in the extreme fibres of the flanges.

The *average* vertical shear stress is found by dividing the total transverse shear by the web area (depth of beam × web thickness). The *maximum* vertical shear stress—at the neutral axis—is about $12\frac{1}{2}\%$ greater.

The " maximum distributed loads " tabulated on pages 30 and 174 are based on an average shear stress of only 4 tons per square inch, so that the maximum stress shall not exceed $4\frac{1}{2}$ tons per square inch.

If t = Thickness of the cross section at the point under consideration,
A = Area of portion of section between the point and the extreme fibre,
a = Distance of the centre of gravity of this area, from the neutral axis,
I = The moment of inertia of the whole section about the neutral axis,
S = Total transverse shear (*i.e.*, vertical shear in a horizontal girder),
s = Shear stress intensity (transverse and longitudinal),
then $s = (S \times A \times a) \div (t \times I)$.

This formula has been used for obtaining the rivet shear factors tabulated in the plated girder tables on page 250, assuming a shear or bearing stress of $5\frac{1}{2}$ or 11 tons respectively.

3. COMBINED EFFECT OF FLEXURAL AND SHEAR STRESSES.

(i) In cases where high flexural and shear stresses occur at the same point,* besides considering them independently, it is necessary also to consider their combined effect. They may be resolved at any point into two stresses, compressive and tensile respectively, one of which is the greatest stress to which the material is subjected at that point. These two stresses are termed the " Principal Stresses." Their values are $\frac{f}{2} \pm \sqrt{s^2 + \frac{f^2}{4}}$ where f = the flexural stress and s = the vertical shear stress at that point.

The principal compressive and tensile stresses attain their maxima at the junctions between the web and the upper and lower flanges (*i.e.*, at the fillets) respectively ; these maxima are of equal numerical value.

* *E.g.*, Girders subjected to heavy concentrated loads, girders with " fixed " ends and heavily loaded cantilevers, including grillage beams and template girders.

Consequently, as the allowable compressive stress in the web (owing to its buckling effect) is less than the allowable tensile stress, the latter may be disregarded.

To calculate the maximum principal compressive stress in a beam, we have first to determine at what position in the length of the beam the combined effect of shear and flexural stress attains its maximum* and then to determine the value of the principal compressive stress at the upper fillet in this cross section.

To find the values of f and s at this point, we have :—

If F = the extreme fibre stress in the cross section under consideration,
d = total depth of beam,
c = depth of web between fillets, see Fig. 1,

then $f = F \times \frac{c}{d}$

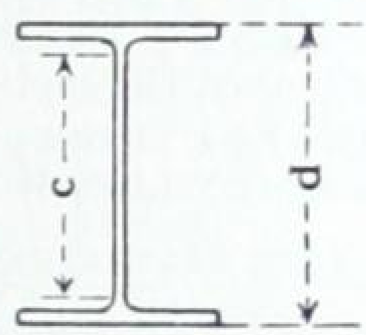


Fig. 1.

N.B.—The values of $\frac{c}{d}$ are tabulated on pages 38 and 175 for Broad Flange Beams and R.S. Joists respectively.

The value of s at this point may be taken as the total transverse shear (at the cross section under consideration) ÷ by the web area, namely, by $d \times t$. where t is the web thickness.

Substituting these values of f and s in the formula on page 60, if the maximum principal compressive stress, thus calculated, exceeds the safe principal compressive stress (tabulated for B.F. Beams and R.S. Joists on pages 38 and 175) then a larger section is required, or else the web of the beam must be suitably reinforced throughout the requisite length up to a point where the stress falls within safe limits.

(ii) The safe principal compressive stresses tabulated on pages 38 and 175 are calculated on the following basis :—

The web is assumed to be analogous to a series of struts and ties perpendicular to each other and set at an angle of 45° to the neutral axis. The ties brace the struts, and this is assumed to be equivalent to halving the effective length of the struts. Accordingly, the safe principal compressive stress is taken to be the safe compressive stress on a column with fixed ends, of length equal to one-half of the depth of the web measured between the fillets at an angle of 45° to the axis of the beam; viz., of length $\frac{c}{2} \times \sqrt{2}$. The stresses are calculated by Fidler's formula with a factor of safety of 4, as tabulated on page 95.

* This is usually self-evident, and, for the majority of the commoner cases of loading, can be readily deduced from the shearing force and bending moment diagrams given on pages 45 to 48.

(iii) The shear stress (s_r)—resulting from combined flexural stress and vertical shear stress at any point—is at a maximum at an angle of 45° to the principal stresses, in which direction its magnitude is $\sqrt{s^2 + \frac{f^2}{4}}$, namely, half the algebraic difference between the principal stresses. It should not exceed $4\frac{1}{2}$ tons per square inch.

In any cross section the value of s_r will always be greatest at the junction of web and flange, and occurs normally, but not necessarily, in the same cross section as that in which the principal compressive stress attains its maximum.

4. TRANSVERSE STRESS.

When a girder carries a heavy concentrated load it is necessary not only to consider the combined effect of the flexural and shear stresses, but also the liability of the web to buckle locally as a column. This liability has always to be considered in template or grillage beams, but may also arise with any exceptionally short heavily loaded beam, either beneath the load or at the bearings.

Such cases must be examined from two points of view :—

(i) If the pressure on the web exceeds the usual allowance of 11 tons per square inch (bearing value), the bearing area must be increased by applying plates or stiffeners properly ground to fit between the flanges.

(ii) If the stress per square inch in the web exceeds its safe compressive stress as a column, either the web area must be increased by plating or stiffeners designed on the lines indicated on page 58 must be added.

The "safe column stresses" for the webs of B.F. Beams and ordinary joists are tabulated on pages 38 and 175 respectively. They are calculated by Fidler's formula for columns with fixed ends with a factor of safety of 4, to be increased by 50% if there is any vibration or impact.

Inasmuch as the pressure on the web is distributed and ultimately converted into a shear stress, it may be assumed for purposes of calculation that the pressure is spread over a greater length than the actual length of web under compression.

Thus, if d is the depth of the beam and l is the actual length of web in compression, then, in the case of an end reaction (Fig. 2), the pressure may be regarded as distributed over a length $l + 0 \cdot 3\ d$.

In the case of a concentrated load as in Fig. 3, this addition to the effective length may be regarded as occurring on both sides, so that the length under compression may be taken as $l + 0 \cdot 6\ d$.

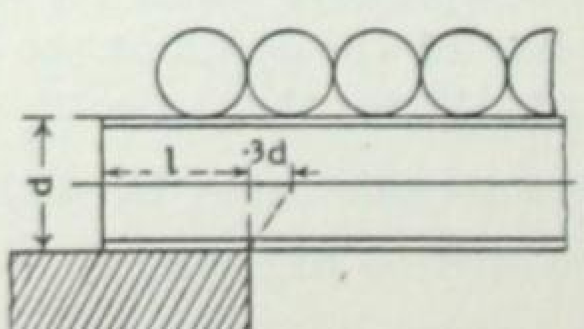


Fig. 2.

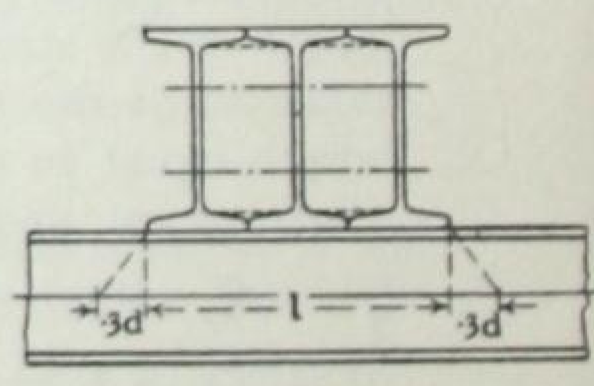


Fig. 3.

B.F. BEAMS, GREY PROCESS, AS TEMPLATES.

Rolled steel beams can often be employed with advantage to distribute a heavy load over a sufficient area of a brick wall or pier, as illustrated in Figs. 1 and 2.

In the table below, we shew what sections and lengths of B.F. Beams, Grey Process, are suitable for various loads, and for an allowable pressure on the brickwork of 5, 8 or 12 tons per square foot, as the case may be. These are the maximum pressures ordinarily allowed (see page 57 § 11), for respectively —

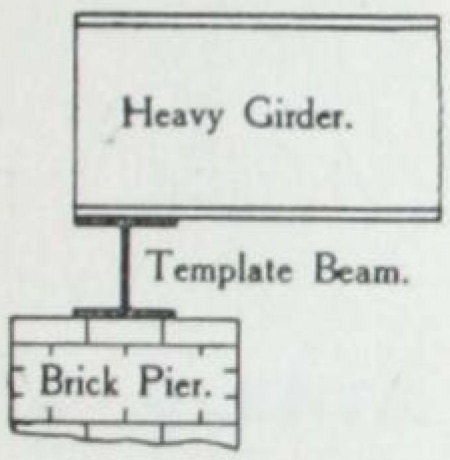


Fig. 1.

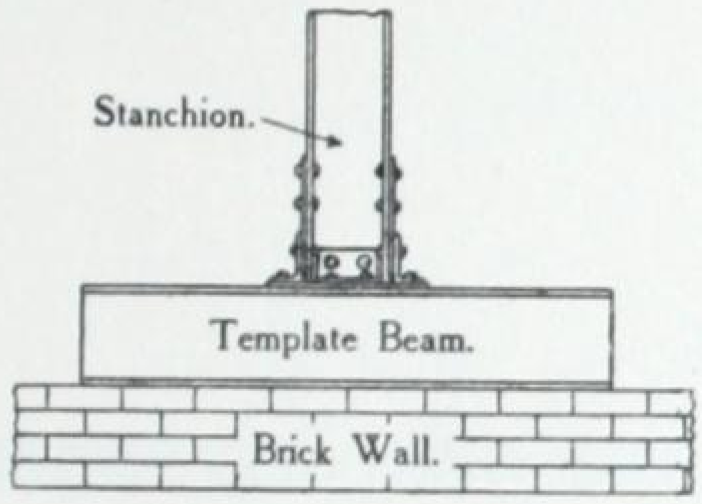


Fig. 2.

(i) Ordinary bricks in cement (5 tons).

(ii) Hard (including "London Stock") Bricks in cement (8 tons).

(iii) Blue bricks in cement (12 tons).

USE OF TABLE.—Suppose a steel template is required to distribute a load of 50 tons, on hard bricks laid in cement, the allowable pressure being 8 tons per square foot.

The table shews that a B.F. Beam 14″ × 12″ × 101 lb. × 6′ 11″ long would be suitable for a load of 54·6 tons. For a load of 50 tons, the length can be proportionately reduced, viz., to 6′ 4″.

Alternatively, since the table shews that a beam 8½″ × 8½″ × 48 lb. × 4′ 4″ long would be suitable for a load of 25 tons, a *pair* of these could be used instead for the 50-ton load, if more convenient.

When used in pairs, template beams should be joined together with separators, as shewn on page 74 (or, for ordinary joists, on page 82).

MODE OF CALCULATION.—The template beam is regarded as a double cantilever, carrying a uniformly distributed upward load; and the section of the template beam is determined by the principal compressive stress resulting from the combined flexural, shear and transverse stresses in the web. For the loads tabulated below, web stiffeners are *not* required. For fuller explanation, see page 58.

STIFFENERS

TEMPLATE SECTION.		SAFE LOADS, AND CORRESPONDING LENGTHS AND WEIGHTS FOR ALLOWABLE PRESSURES OF								
		5 Tons per sq. foot.			8 Tons per sq. foot.			12 Tons per sq. foot.		
Nominal Size.	Wt. per Foot.	Safe Load on Template.	Length of Template.	Weight of Template.	Safe Load on Template.	Length of Template.	Weight of Template.	Safe Load on Template.	Length of Template.	Weight of Template.
Inches.	Lb.	Tons.		Lb.	Tons.		Lb.	Tons.		Lb.
5½ × 5½	23	10·9	4′ 9″	109	12·2	3′ 4″	77	13·3	2′ 5″	56
6 × 6	25	11·8	4′ 10″	121	13·3	3′ 5″	85	14·2	2′ 5″	60
7 × 7	35	16·3	5′ 7″	195	18·3	3′ 11″	137	19·2	2′ 9″	96
8 × 8	44	20·3	6′ 2″	271	22·7	4′ 4″	191	23·9	3′ 0″	132
8½ × 8½	48	22·5	6′ 3″	300	25·0	4′ 4″	208	26·0	3′ 0″	144
10 × 10	61	28·8	7′ 0″	427	31·7	4′ 10″	295	32·0	3′ 3″	198
11 × 11	76	35·2	7′ 8″	582	38·6	5′ 3″	399	39·6	3′ 7″	272
12 × 12	81	38·1	7′ 9″	628	41·3	5′ 3″	425	42·2	3′ 7″	290
14 × 12	101	48·8	9′ 11″	1002	54·6	6′ 11″	699	57·1	4′ 10″	488
16 × 12	110	...	...	...	59·4	7′ 7″	833	62·0	5′ 3″	578
18 × 12	122	...	...	...	67·7	8′ 7″	1047	72·0	6′ 1″	742
20 × 12	135	...	...	...	76·8	9′ 9″	1316	82·7	7′ 0″	945

CLEATS, FISHPLATES, AND SEPARATORS.

CLEATS AND FISHPLATES

BEAM SECTIONS.

The connections shown for B.F. Beams, on pages 67 to 73, are designed to suit the Din (medium) weights. They can readily be adapted to suit the other weights.

SAFE END REACTIONS.

The stated safe end reactions are the shear values of the connecting bolts, taken as :—

4 tons per square inch ... ... in Web Cleats.
2 tons per square inch ... ... in the Upper Flange Cleat.

A low value is taken in the latter case, on account of the considerable tensile stress in these bolts.

(N.B.—The shearing and bearing values of the web rivets, taken as $5\frac{1}{2}$ and 11 tons per square inch respectively, are greater than the shear values of the bolts.)

In the absence of diagonal wind bracing, web cleats are useful for stiffening the structure, especially during erection. They should not therefore be dispensed with, even when the beam rests on a bracket designed to support the entire end load.

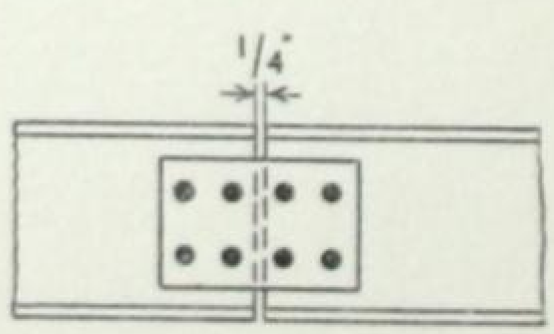
CLEATS.

The supporting bracket or lower flange cleat is not shown in these drawings because it will usually be riveted to the supporting member. The upper flange cleats here shown have for their primary function to provide a more rigid connection, in the interest of general stability.

The stated weights are finished weights, exclusive of field bolts or rivets.

FISHPLATES.

These are suitable for an ordinary connection over a stanchion or other support : but when a joint is not over a support, flange plates must be fitted, at least equal to the calculated bending moment at that point (it is more usual to design such splices to equal the full resistance moment of the beam). It is usual to allow about $\frac{1}{4}''$ clearance between the abutting ends of the beams, thus :—



In the case of a long stretch of girders, as in crane runways, provision must be made for expansion—usually by slotting the holes in the fishplates, and making an appropriate allowance in the girder lengths. The variation in length caused by a rise or fall in temperature of 50° Fahrenheit is $\frac{1}{8}''$ in $31\frac{1}{2}$ feet.

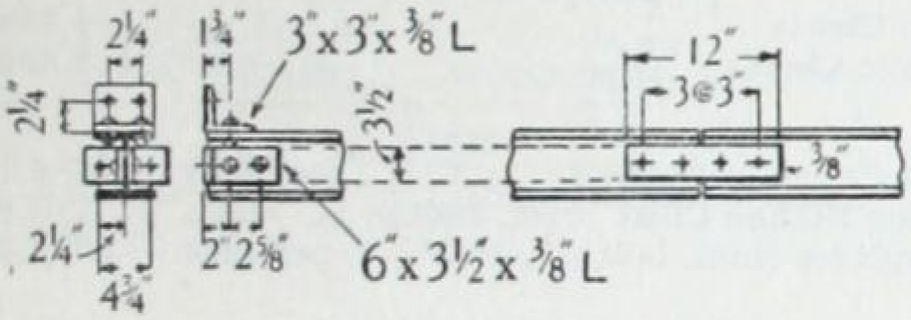
The stated weights are the calculated weights of the plates, bolts, and nuts, *less* holes in plates and beams.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.

For explanatory notes, see page 66.

B.F. BEAM 5″ × 5″.



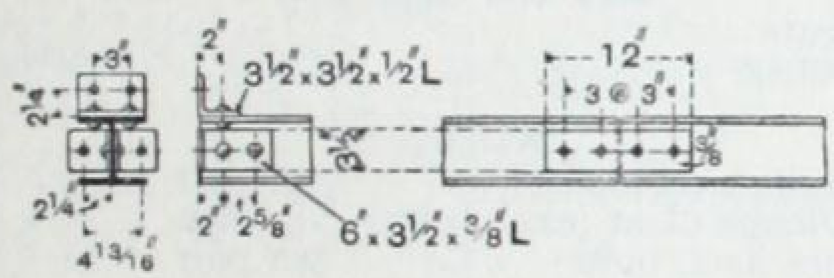
Safe End Reactions.

Web Cleats	3·5 tons.
Flange Cleat	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	7·2 lb.
Upper Flange Cleat (excl. bolts) ...	each	2·7 lb.
Fishplates (incl. bolts) ...	per pair	11·2 lb.

B.F. BEAM 5½″ × 5½″.



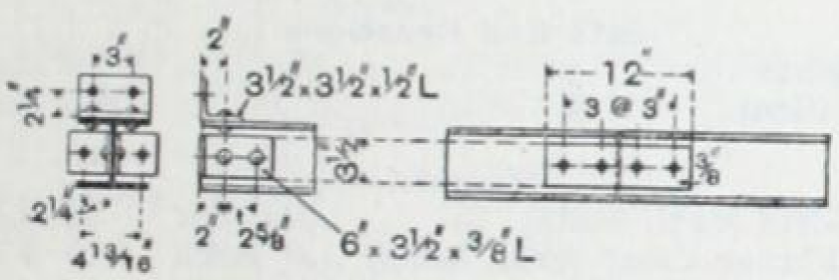
Safe End Reactions.

Web Cleats	3·5 tons.
Flange Cleat	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	7·2 lb.
Upper Flange Cleat (excl. bolts) ...	each	5·5 lb.
Fishplates (incl. bolts) ...	per pair	11·2 lb.

B.F. BEAM 6″ × 6″.



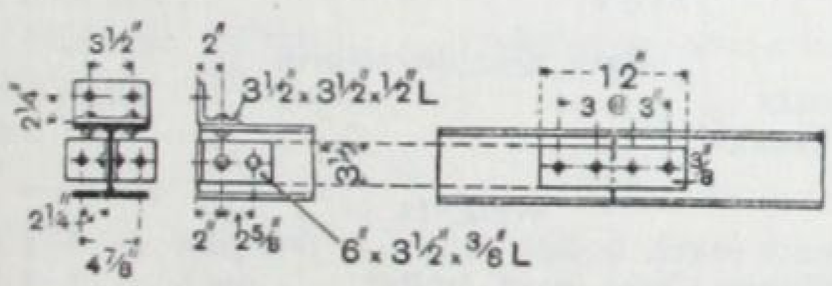
Safe End Reactions.

Web Cleats	3·5 tons.
Flange Cleat	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	7·2 lb.
Upper Flange Cleat (excl. bolts) ...	each	5·8 lb.
Fishplates (incl. bolts) ...	per pair	11·2 lb.

B.F. BEAM 6¼″ × 6¼″.



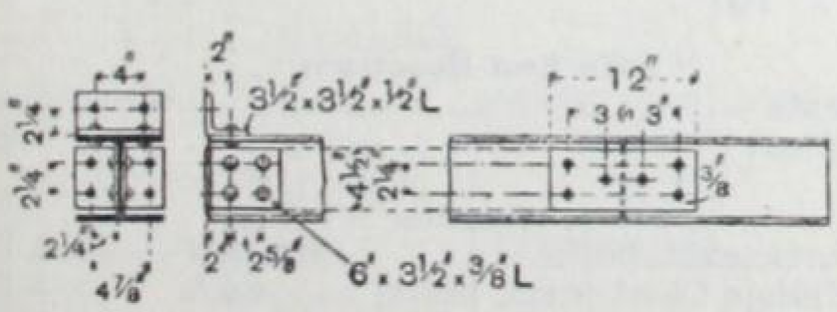
Safe End Reactions.

Web Cleats	3·5 tons.
Flange Cleat	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	7·2 lb.
Upper Flange Cleat (excl. bolts) ...	each	6·2 lb.
Fishplates (incl. bolts) ...	per pair	11·2 lb.

B.F. BEAM 7″ × 7″.



Safe End Reactions.

Web Cleats	7·0 tons.
Flange Cleat	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	9·6 lb.
Upper Flange Cleat (excl. bolts) ...	each	6·9 lb.
Fishplates (incl. bolts) ...	per pair	14·9 lb.

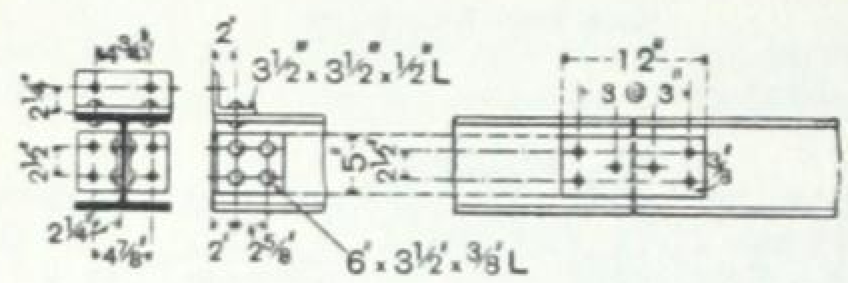
Rivets and Bolts, 3/4″ dia. Holes, 13/16″ dia. For Dimensions of Beams, see p. 16.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.—Continued.

For explanatory notes, see page 66.

B.F. BEAM 8″ × 8″.



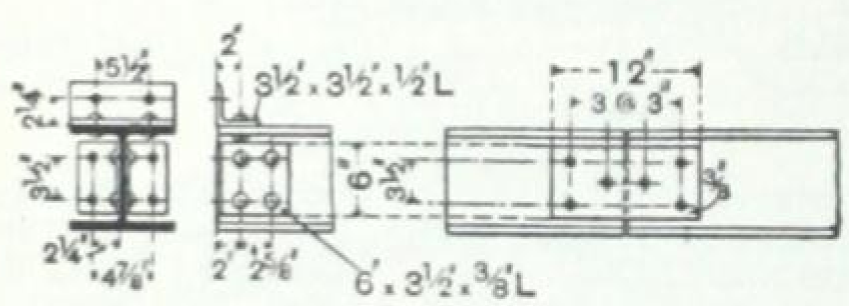
Safe End Reactions.

Web Cleats ...	... ...	7·0 tons.
Flange Cleat	... ...	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	10·6 lb.
Upper Flange Cleat (excl. bolts) ...	each	7·7 lb.
Fishplates (incl. bolts) ...	per pair	16·2 lb.

B.F. BEAM $8\frac{1}{2}$″ × $8\frac{1}{2}$″.



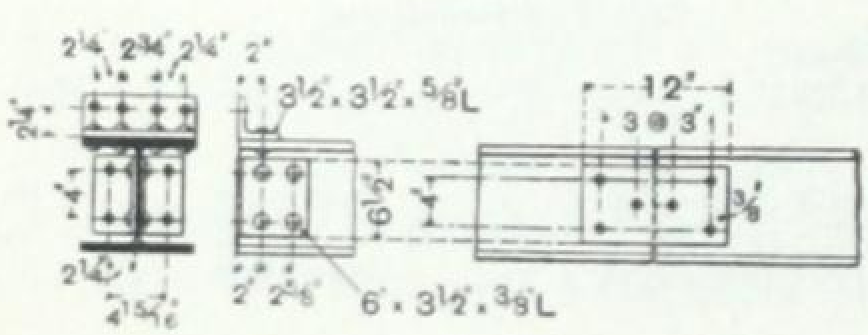
Safe End Reactions.

Web Cleats ...	... ...	7·0 tons.
Flange Cleat	... ...	1·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	12·5 lb.
Upper Flange Cleat (excl. bolts) ...	each	8·4 lb.
Fishplates (incl. bolts) ...	per pair	18·7 lb.

B.F. BEAM $9\frac{1}{2}$″ × $9\frac{1}{2}$″.



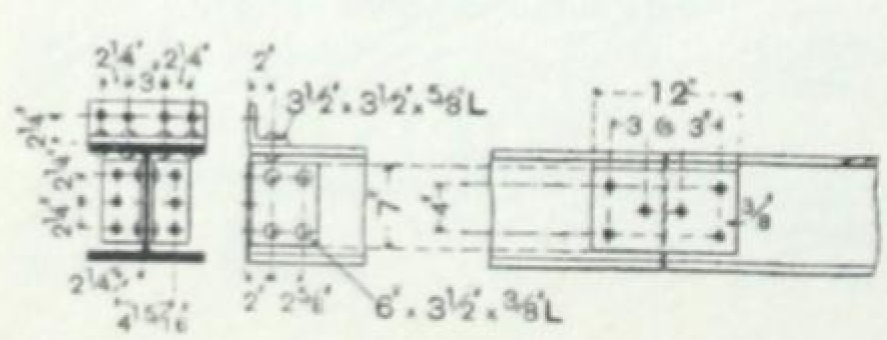
Safe End Reactions.

Web Cleats ...	... ...	7·0 tons.
Flange Cleat	... ...	3·5 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	13·5 lb.
Upper Flange Cleat (excl. bolts) ...	each	11·4 lb.
Fishplates (incl. bolts) ...	per pair	20·0 lb.

B.F. BEAM 10″ × 10″.



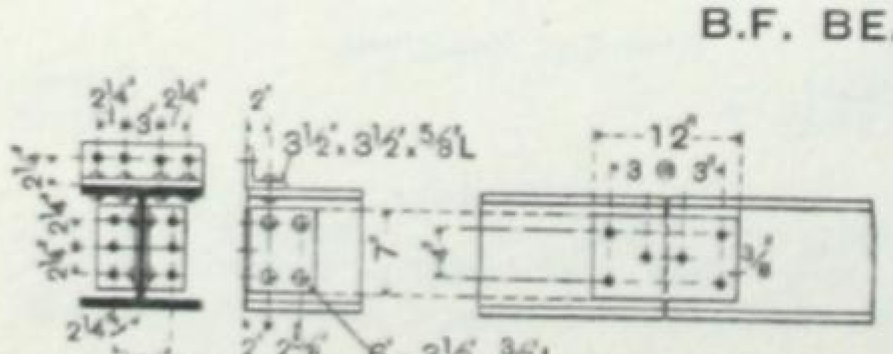
Safe End Reactions.

Web Cleats ...	... ...	10·6 tons.
Flange Cleat	... ...	3·5 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	14·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	11·8 lb.
Fishplates (incl. bolts) ...	per pair	21·2 lb.

B.F. BEAM $10\frac{1}{4}$″ × $10\frac{1}{4}$″.



Safe End Reactions.

Web Cleats ...	... ...	10·6 tons.
Flange Cleat	... ...	3·5 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	14·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	12·3 lb.
Fishplates (incl. bolts) ...	per pair	21·2 lb.

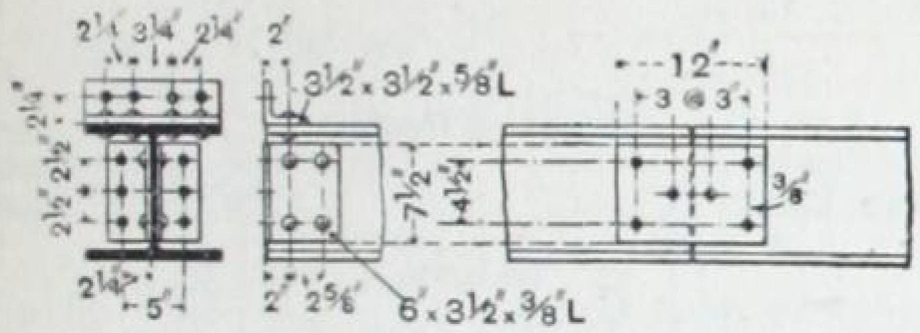
Rivets and Bolts, 3/4″ dia. Holes, 13/16″ dia. For Dimensions of Beams, see pp. 16, 17.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.—Continued.

For explanatory notes, see page 66.

B.F. BEAM 11″ × 11″.



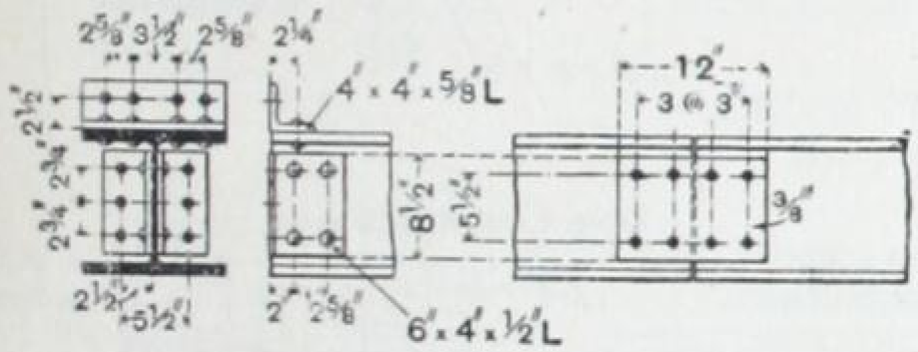
Safe End Reactions.

Web Cleats ...	... ...	10·6 tons.
Flange Cleat	... ...	3·5 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	15·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	13·1 lb.
Fishplates (incl. bolts) ...	per pair	22·5 lb.

B.F. BEAM 12″ × 12″.



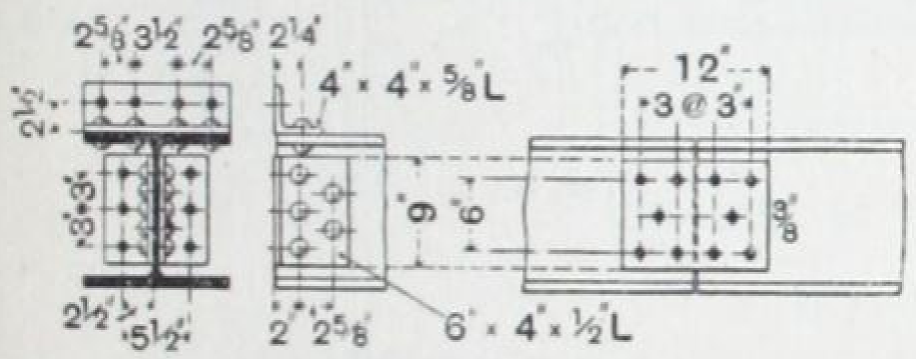
Safe End Reactions.

Web Cleats ...	... ...	14·4 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	23·9 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	28·8 lb.

B.F. BEAM 12½″ × 12″.



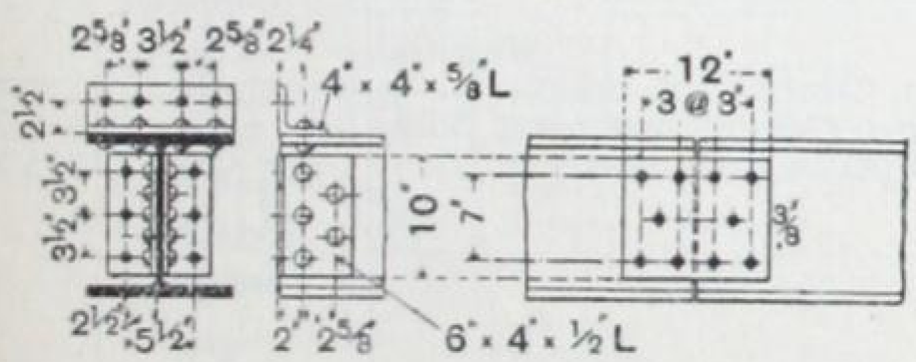
Safe End Reactions.

Web Cleats ...	... ...	14·4 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	25·7 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	31·8 lb.

B.F. BEAM 13½″ × 12″.



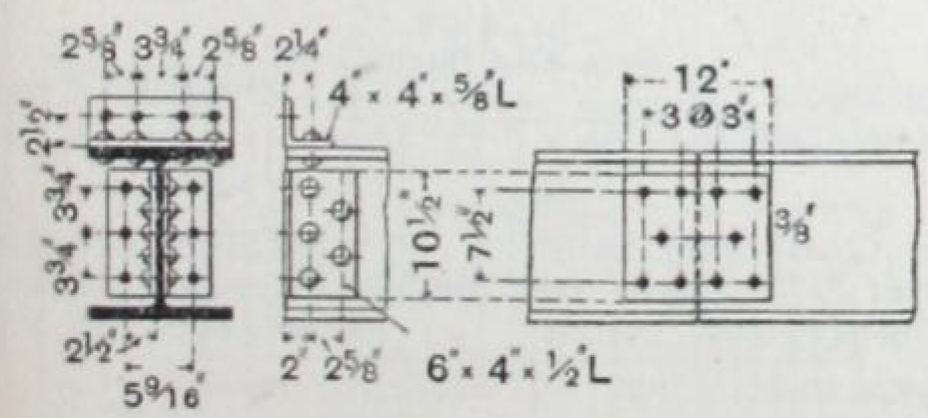
Safe End Reactions.

Web Cleats ...	... ...	14·4 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	28·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	34·3 lb.

B.F. BEAM 14″ × 12″.



Safe End Reactions.

Web Cleats ...	... ...	14·4 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	29·8 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	35·6 lb.

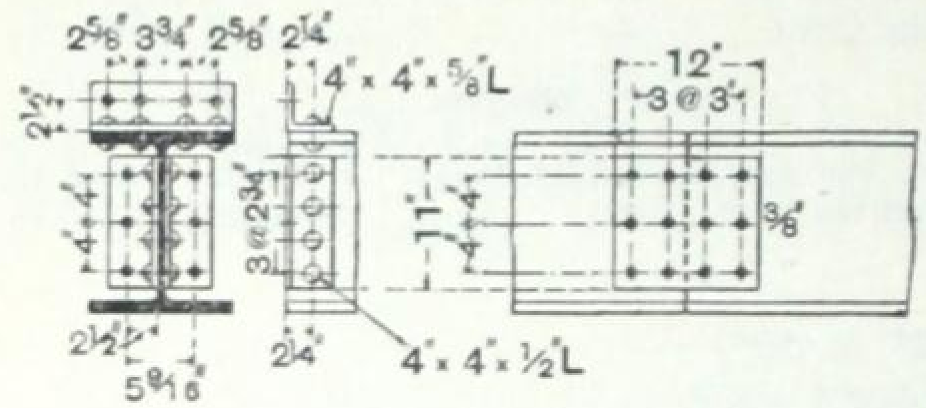
Section 11″×11″	...	Rivets and bolts, 3/4″ dia., Holes 13/16″.
Sections 12″—14″	...	Rivets and bolts, 7/8″ dia., Holes 15/16″.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.—Continued.

For explanatory notes, see page 66.

B.F. BEAM 15″ × 12″.



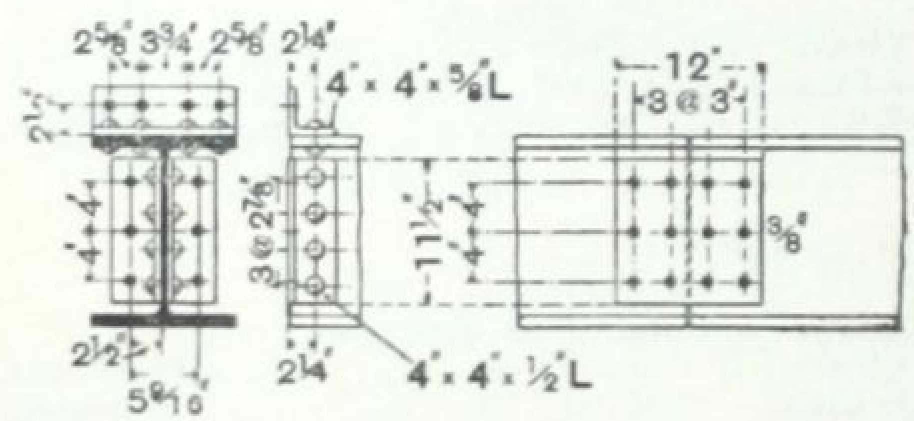
Safe End Reactions.

Web Cleats	14·4 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	24·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	38·6 lb.

B.F. BEAM 16″ × 12″.



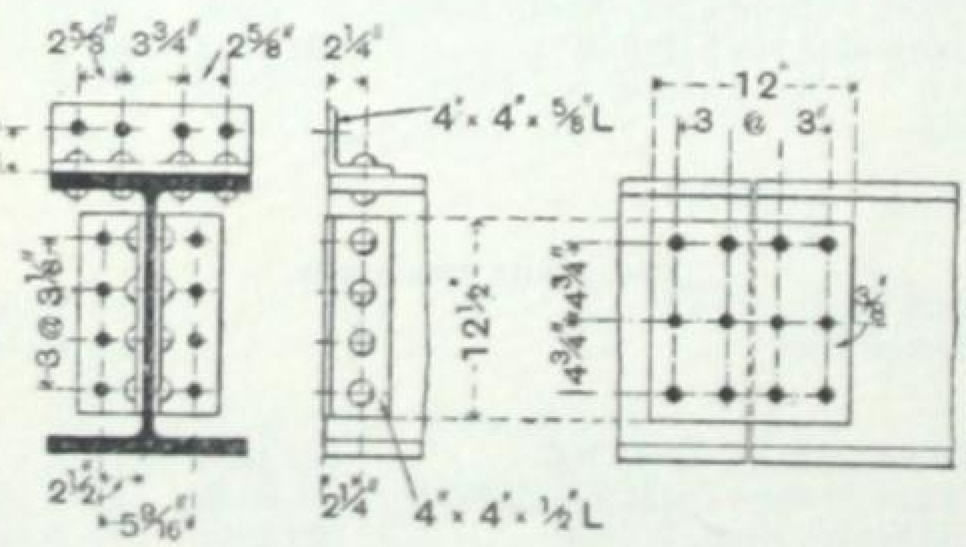
Safe End Reactions.

Web Cleats	14·4 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	25·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	39·9 lb.

B.F. BEAM 17″ × 12″.



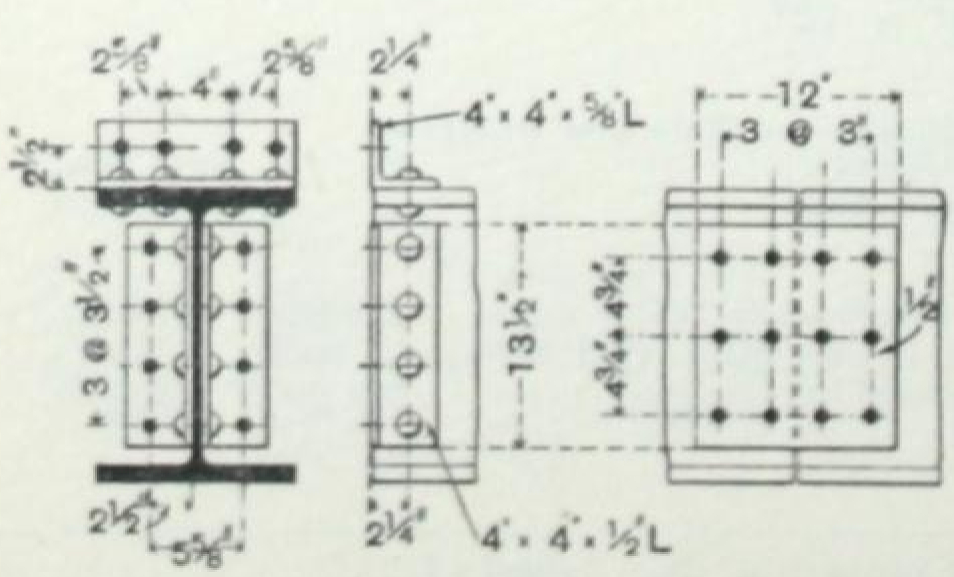
Safe End Reactions.

Web Cleats	19·2 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	27·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	42·5 lb.

B.F. BEAM 18″ × 12″.



Safe End Reactions.

Web Cleats	19·2 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	29·5 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	56·5 lb.

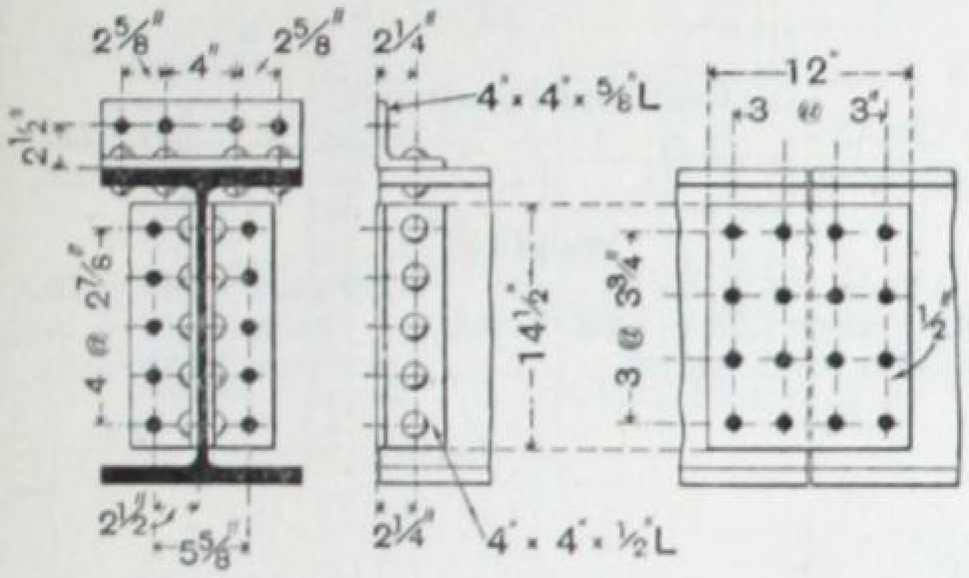
Rivets and Bolts, 7/8″ dia. Holes, 15/16″ dia. For Dimensions of Beams, see p. 18.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.—Continued.

For explanatory notes, see page 66.

B.F. BEAM 19″ × 12″.



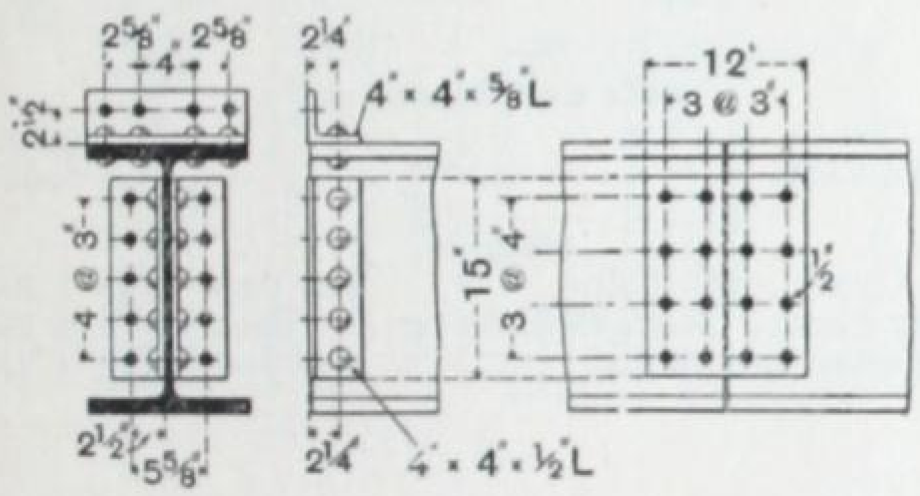
Safe End Reactions.

Web Cleats ...	... ...	24·0 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	31·9 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	63·4 lb.

B.F. BEAM 20″ × 12″.



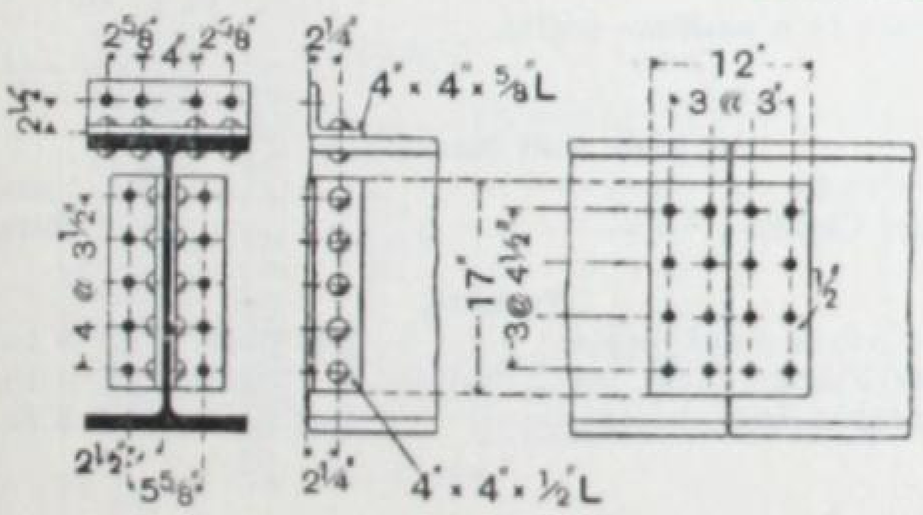
Safe End Reactions.

Web Cleats ...	... ...	24·0 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	33·0 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	65·1 lb.

B.F. BEAM 22″ × 12″.



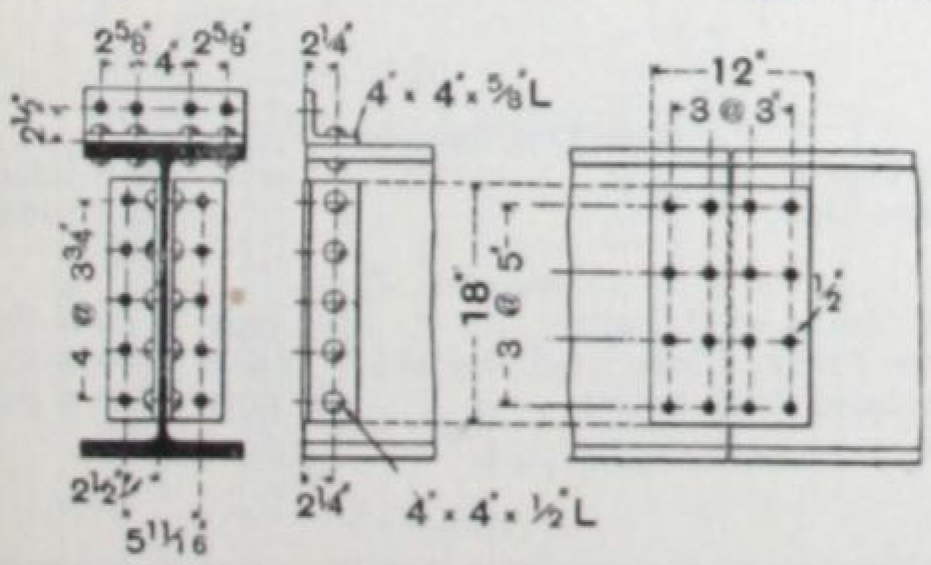
Safe End Reactions.

Web Cleats ...	... ...	24·0 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	37·2 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	71·9 lb.

B.F. BEAM 24″ × 12″.



Safe End Reactions.

Web Cleats ...	... ...	24·0 tons.
Flange Cleat	... ...	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	39·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	75·3 lb.

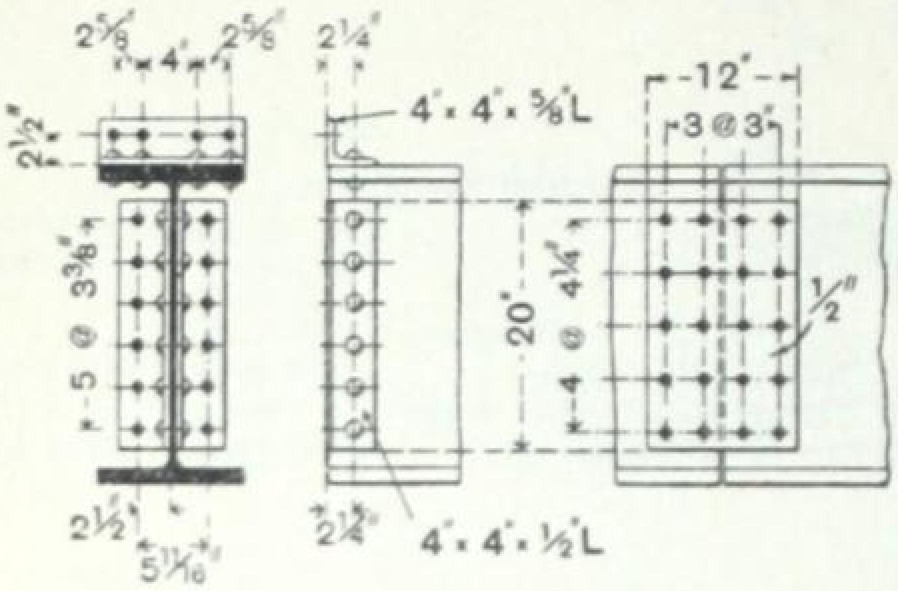
Rivets and Bolts, 7/8″ dia. Holes, 15/16″ dia. For Dimensions of Beams, see p. 19.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.—Continued.

For explanatory notes, see page 66.

B.F. BEAM 26" × 12".



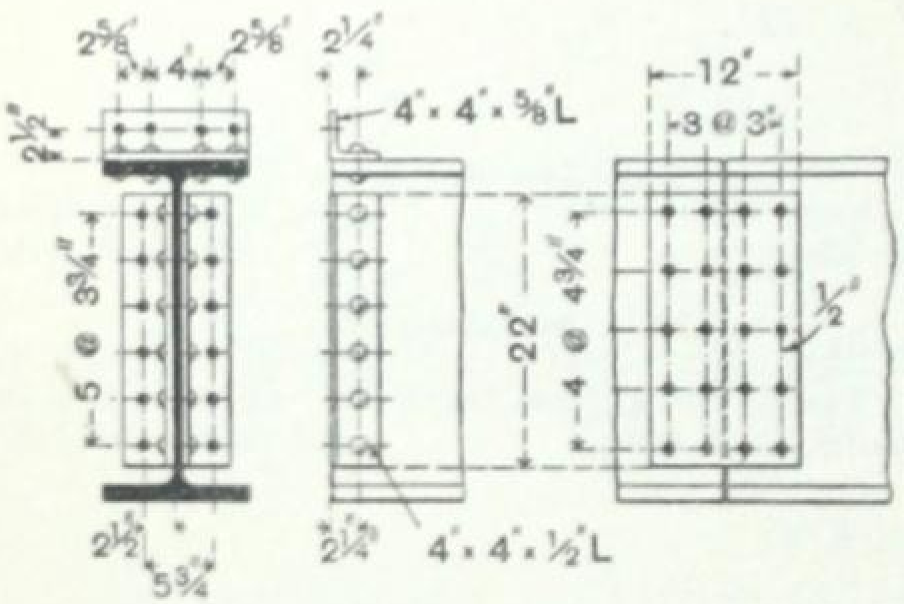
Safe End Reactions.

Web Cleats		28·8 tons.
Flange Cleat		4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	43·8 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	85·6 lb.

B.F. BEAM 28" × 12".



Safe End Reactions.

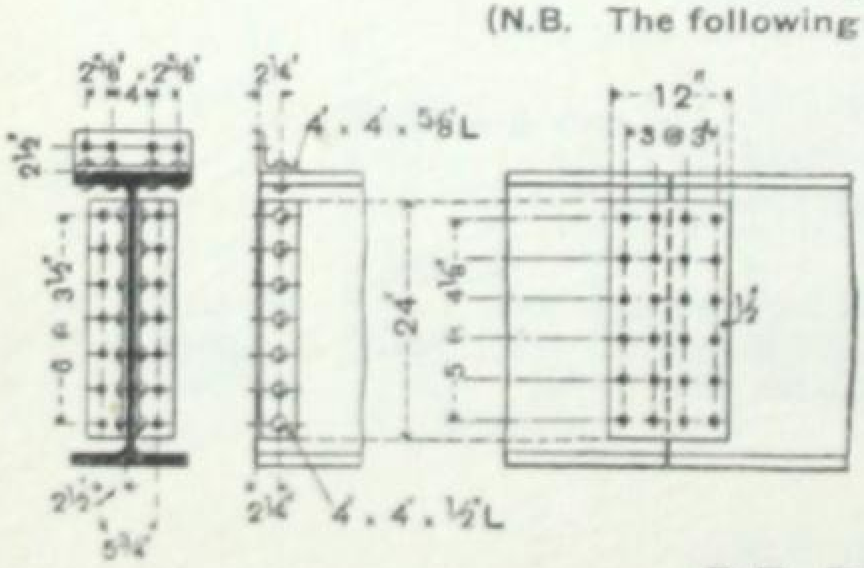
Web Cleats		28·8 tons.
Flange Cleat		4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	48·1 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	92·4 lb.

B.F. BEAM 30" × 12"

(N.B. The following drawings are to a smaller scale).



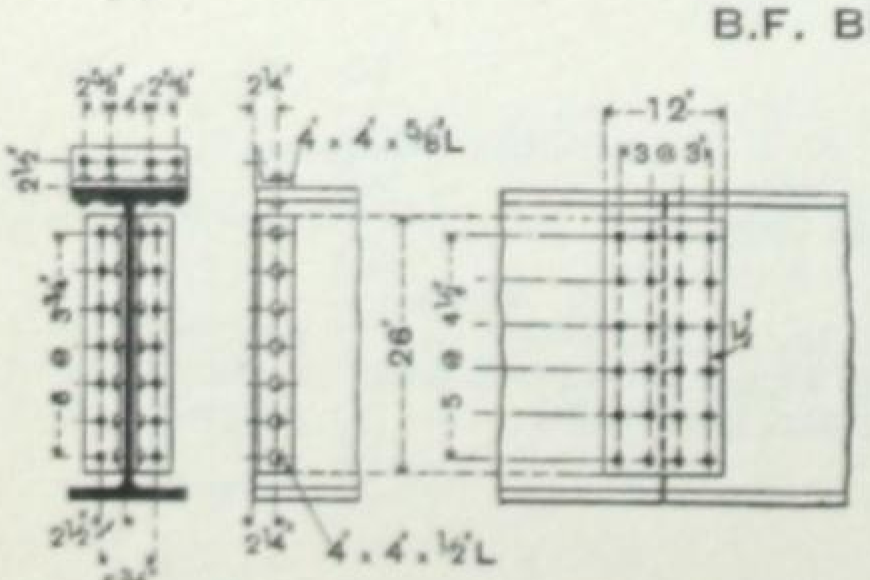
Safe End Reactions.

Web Cleats		33·6 tons.
Flange Cleat		4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	52·5 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	102·8 lb.

B.F. BEAM 32" × 12".



Safe End Reactions.

Web Cleats		33·6 tons.
Flange Cleat		4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	56·8 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	109·6 lb.

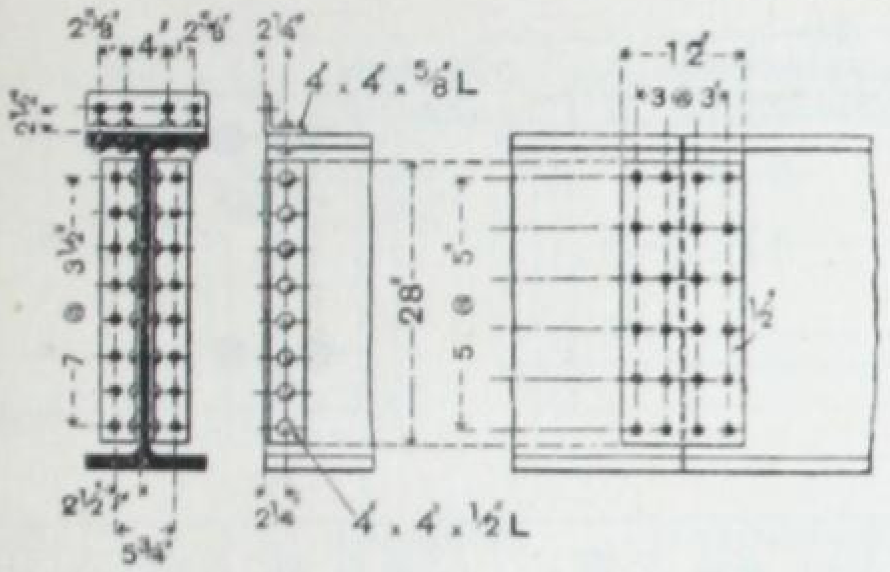
Rivets and Bolts, 7/8" dia. Holes, 15/16" dia. For Dimensions of Beams, see pp. 19, 20.

BROAD FLANGE BEAMS, GREY PROCESS.

STANDARD GIRDER CONNECTIONS.—Continued.

For explanatory notes, see page 66.

B.F. BEAM 34″ × 12″.



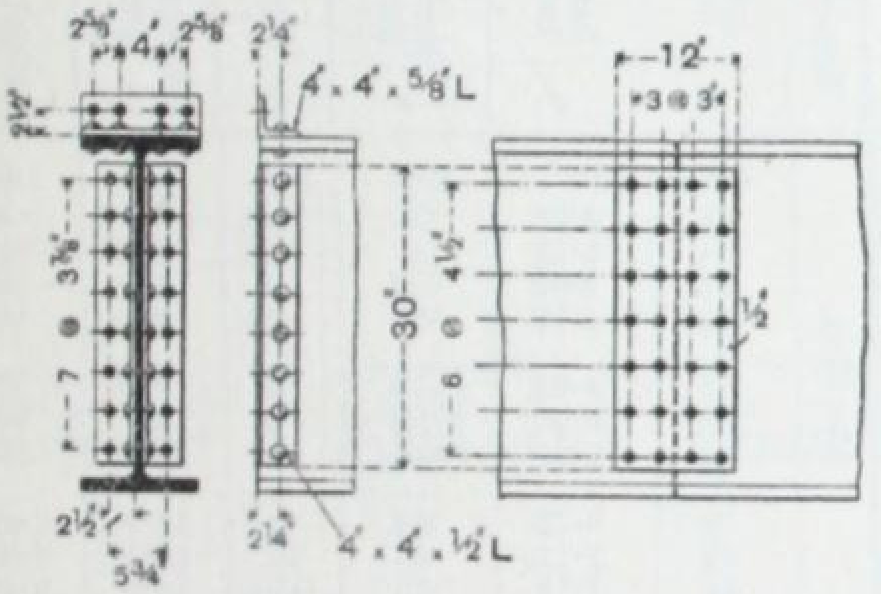
Safe End Reactions.

Web Cleats	38·4 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	61·2 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	116·4 lb.

B.F. BEAM 36″ × 12″.



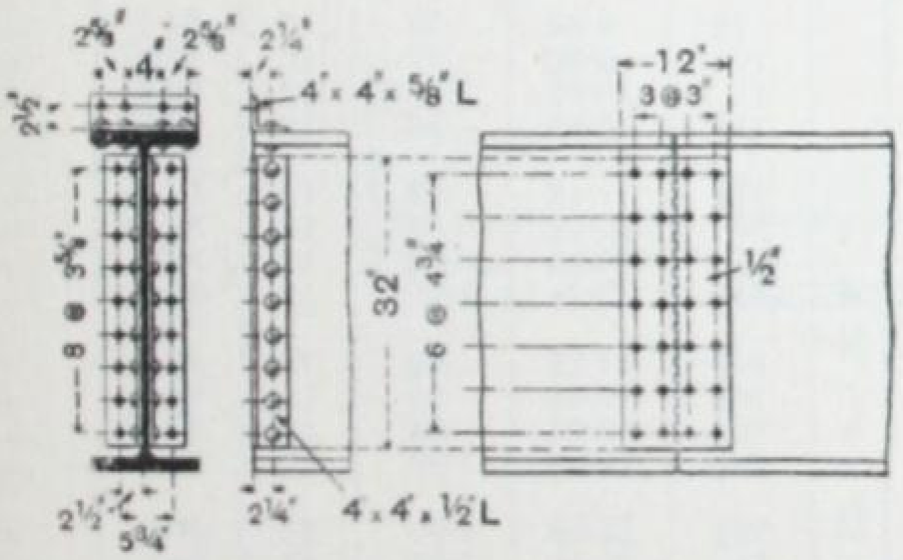
Safe End Reactions.

Web Cleats	38·4 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	65·5 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	126·7 lb.

B.F BEAM 38″ × 12″.



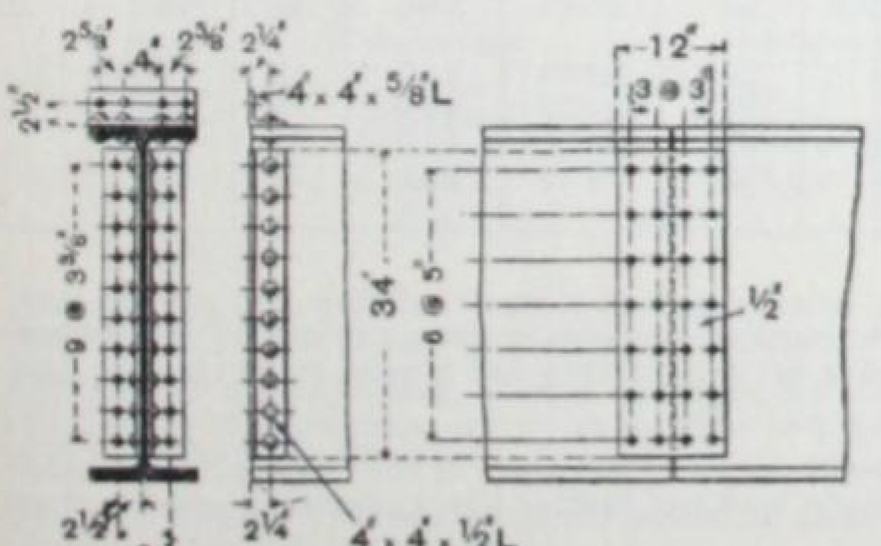
Safe End Reactions.

Web Cleats	43·2 tons.
Flange Cleat	4·8 tons.

Weights.

Web Cleats (excl. bolts) ...	per pair	69·9 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	133·5 lb.

B.F. BEAM 40″ × 12″.



Safe End Reactions.

Web Cleats	48·0 tons.
Flange Cleat	4·8 tons.

Weights.

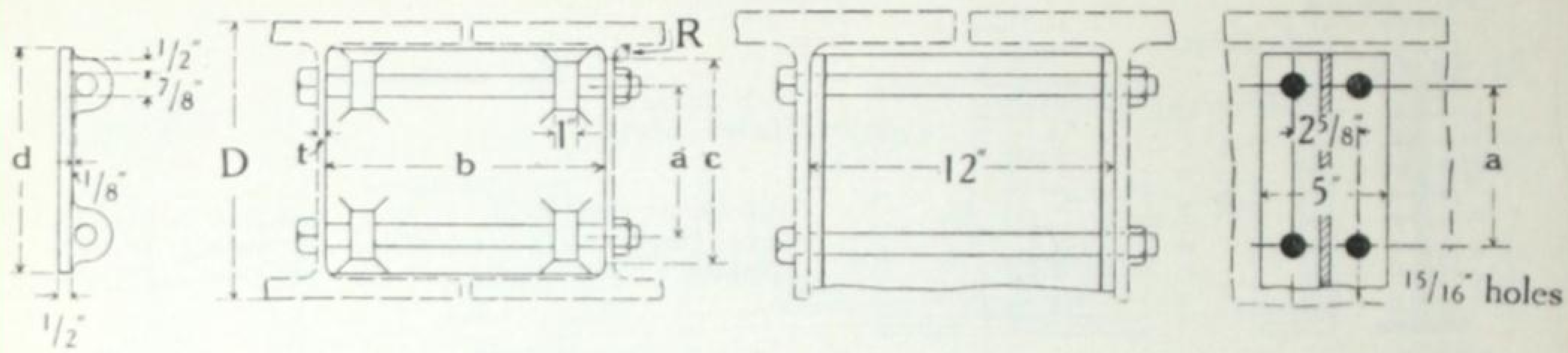
Web Cleats (excl. bolts) ...	per pair	74·4 lb.
Upper Flange Cleat (excl. bolts) ...	each	16·5 lb.
Fishplates (incl. bolts) ...	per pair	140·3 lb.

Rivets and Bolts, 7/8″ dia. Holes, 15/16″ dia. For Dimensions of Beams, see p. 20.

SEPARATORS

FOR BROAD FLANGE BEAMS, GREY PROCESS.

For Separators for R.S. Joists, see page 82.



Nominal Size.	Weight per Foot.	Web Thickness.	Centres of Webs.	Overall width of Two Beams.	Bolts.	Bolt Centres. a	Separator.	Overall Depth. d	Parallel Depth. c	Radius of Corners. R	Breadth. b	Weight of One.	Weight per 1" extra width.
Inches.	Lb.	Ins.	Ins.	Ins.		Ins.		Ins.	Ins.	Ins.	Ins.	Lb.	Lb.
5 × 5	18	·26	5·01	9·73	2 Bolts ⅝" diam.	1¾	Cast Iron.	3¾	3·08	·39	4½	4·0	·46
5½ × 5½	23	·31	5·81	11·32		2		4¼	3·62	·47	5½	5·5	·56
6 × 6	25	·31	6·31	12·22		2¼		4⅝	4·02	·47	6	6·0	·61
6½ × 6½	31	·35	6·60	12·90		2½		4¾	4·13	·53	6½	6·4	·65
7 × 7	35	·35	7·35	14·44	2 Bolts ¾" diam.	2½		5½	4·92	·53	7	7·6	·75
8 × 8	44	·39	8·39	16·26		3		6⅛	5·43	·59	8	9·0	·84
8½ × 8½	48	·39	9·14	17·80		4		6⅞	6·22	·59	8½	10·6	·94
9½ × 9½	59	·43	9·93	19·38		4½		7⅜	6·73	·65	9½	11·9	1·01
10 × 10	61	·43	10·43	20·27		5		7⅞	7·13	·65	10	13·1	1·07
10½ × 10½	64	·43	10·68	20·92		5		8¼	7·52	·65	10½	13·9	1·13
11 × 11	76	·47	11·47	22·49		5½		8¾	8·03	·71	11	15·5	1·19
12 × 12	81	·47	12·47	24·28	4 Bolts ⅞" diam.	6	R.S.J. 12" × 5" × 32 lb.	9⅝	8·82	·71	12	24·7	...
12½ × 12	90	·51	12·51	24·32		7		10¼	9·33	·77	12	27·3	...
13½ × 12	92	·51	12·51	24·32		7½		11	10·12	·77	12	29·3	...
14 × 12	101	·55	12·55	24·36		8		11½	10·63	·83	12	30·7	...
15 × 12	102	·55	12·55	24·36		9		12¼	11·42	·83	12	32·7	...
16 × 12	110	·55	12·55	24·36		9		13	12·05	·83	12	34·7	...
17 × 12	112	·55	12·55	24·36		10		14	13·03	·83	12	37·3	...
18 × 12	122	·59	12·59	24·40		11		14¾	13·74	·89	12	39·3	...
19 × 12	124	·59	12·59	24·40		12		15¾	14·72	·89	12	42·0	...
20 × 12	135	·63	12·63	24·44		12½		16½	15·43	·94	12	44·0	...
22 × 12	139	·63	12·63	24·44		14½		18½	17·40	·94	12	49·3	...
24 × 12	152	·67	12·67	24·48		16		20½	19·09	1·00	12	54·0	...
26 × 12	157	·67	12·67	24·48	6 Bolts ⅞" diam.	9		22½	21·06	1·00	12	59·3	...
28 × 12	171	·71	12·71	24·52		10		24	22·76	1·06	12	64·0	...
30 × 12	176	·71	12·71	24·52		11		26	24·72	1·06	12	69·3	...
32 × 12	180	·71	12·71	24·52		12		28	26·69	1·06	12	74·7	...
34 × 12	196	·75	12·75	24·56	8 Bolts ⅞" diam.	8½		29½	28·39	1·12	12	78·7	...
36 × 12	201	·75	12·75	24·56		9		31½	30·35	1·12	12	84·0	...
38 × 12	206	·75	12·75	24·56		9½		33½	32·32	1·12	12	92·0	...
40 × 12	211	·75	12·75	24·56		10½		35½	34·29	1·12	12	94·7	...

USE. Separators are intended to connect two or more joists and usually in such a way that they will act together, even if one is more heavily loaded than the other(s). For this purpose the separators must act as cantilevers, transferring any excess load from one joist to the next; this end is attained if they are ground to fit into the joist fillets and kept in contact with the web by means of bolts.

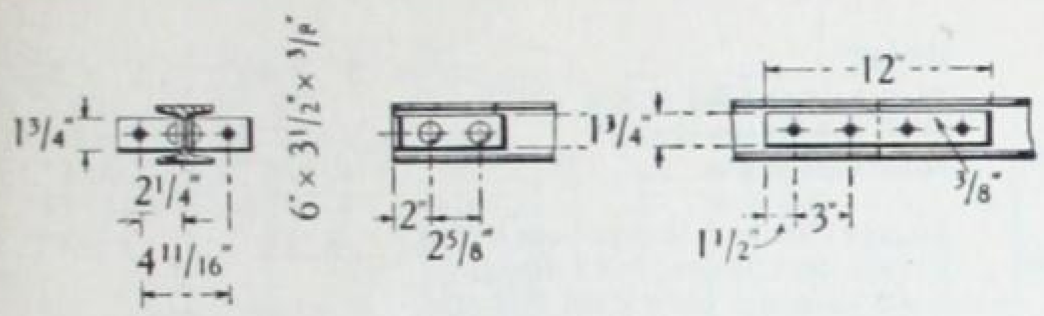
SPACING OF SEPARATORS. This depends on the depth of the girder and the nature of the loading. A common rule is to place separators at supports and under concentrated loads, and not farther apart, centre to centre, than 5 times the depth of the girder.

WEIGHTS. These are approximate. The figures tabulated in the right hand column show the extra weight of the cast iron separators if the beams are spaced 1" farther apart.

BRITISH STANDARD JOISTS.

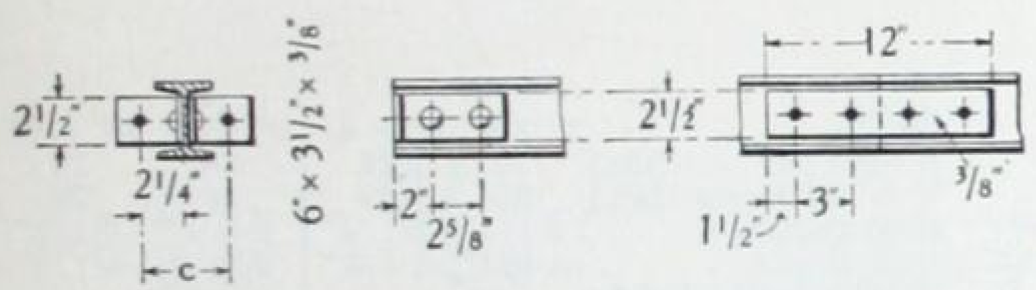
STANDARD GIRDER CONNECTIONS.

Properties, page 172.



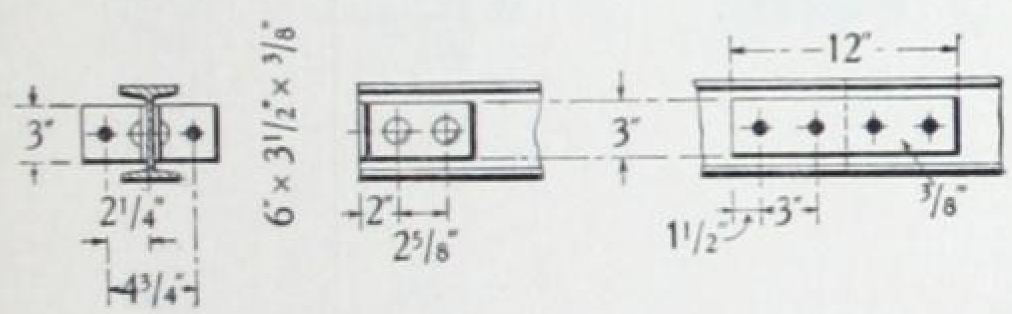
Joist	3″ × 1½″	3″ × 3″
Weight per foot (Lb.) ...	4	8·5
Web thickness (Ins.) ...	·16	·20

Rivets and Bolts, 5/8″ diam.
Web Cleats : Safe End Reaction, 1·8 tons.
,, ,, Weight, 3·40 lb. per pair.
Fishplates : ,, 4·46 ,, ,, ,,

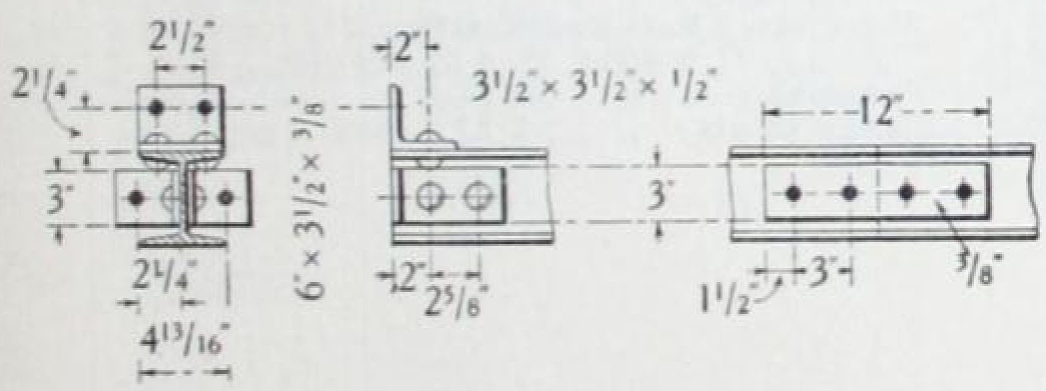


Joist ...	4″ × 1¾″	4″ × 3″	4¾″ × 1¾″
Weight per foot (Lb.)	5	10	6·5
Web thickness (Ins.)	·17	·24	·18
Hole Centres c	4-11/16″	4-3/4″	4-11/16″

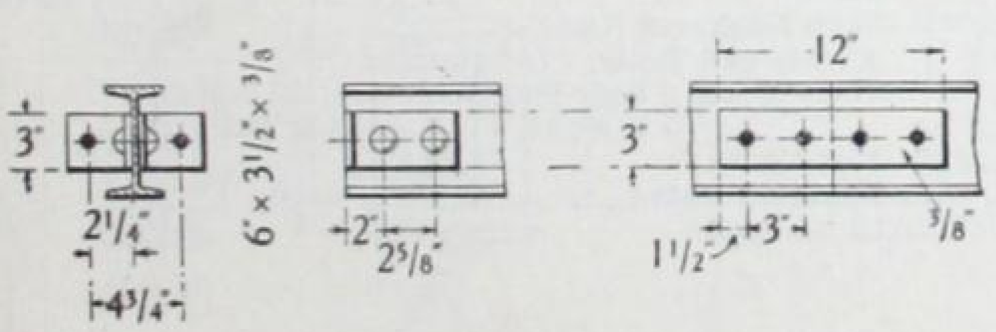
Rivets and Bolts, 5/8″ diam.
Web Cleats : Safe End Reaction, 1·8 tons.
,, ,, Weight, 4·85 lb. per pair.
Fishplates : ,, 6·38 ,, ,, ,,



Joist ... ... 5″ × 3″ × 11 lb.
Web thickness (Ins.) ... ... ·22
Rivets and Bolts, 3/4″ diam.
Web Cleats : Safe End Reaction, 3·5 tons.
,, ,, Weight, 5·82 lb. per pair.
Fishplates : ,, 7·65 ,, ,, ,,



Joist ... ... 5″ × 4½″ × 20 lb.
Web thickness (Ins.) ... ... ·29
Rivets and Bolts, 3/4″ diam.
Web Cleats : Safe End Reaction, 3·5 tons.
,, ,, Weight, 5·82 lb. per pair.
Fishplates : ,, 7·65 ,, ,, ,,
Flange Cleats : ,, 4·12 ,, each.



Joist ... ... 6″ × 3″ × 12 lb.
Web thickness (Ins.) ... ... ·23
Rivets and Bolts, 3/4″ diam.
Web Cleats : Safe End Reaction, 3·5 tons.
,, ,, Weight, 5·82 lb. per pair.
Fishplates : ,, 7·65 ,, ,, ,,

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch, except for the first two groups, where 3 tons only per square inch has been allowed. Value of flange cleats ignored.

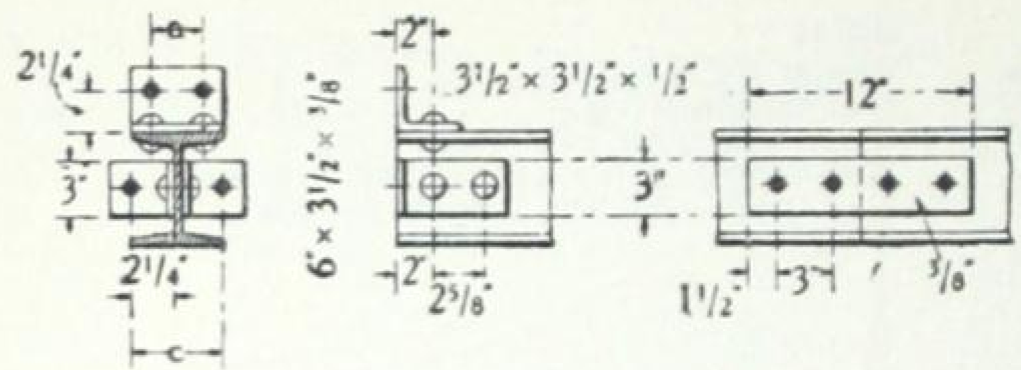
CLEARANCES. Cleats are usually made to project about 1/16″ beyond the cut ends, and about 1/4″ is usually allowed between fish-plated ends.

WEIGHTS. The weights given for fishplates and cleats are before drilling and do not include bolts or rivets.

BRITISH STANDARD JOISTS.

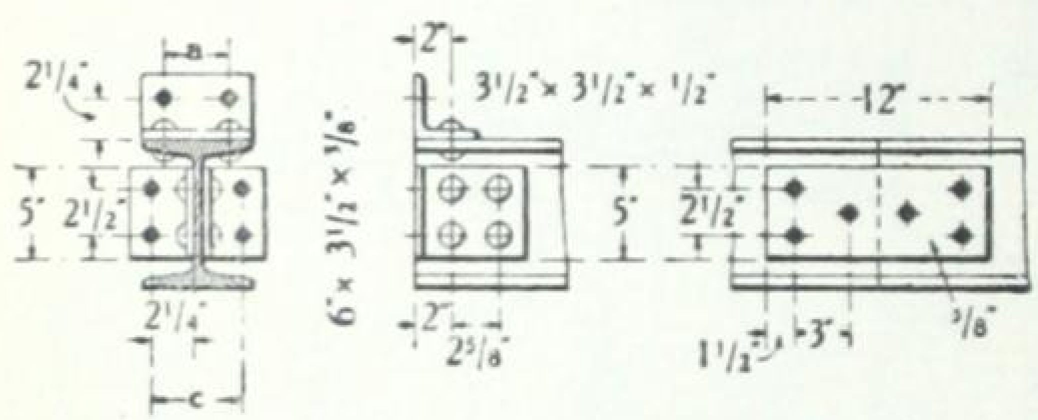
STANDARD GIRDER CONNECTIONS.—Continued.

Properties, page 172.



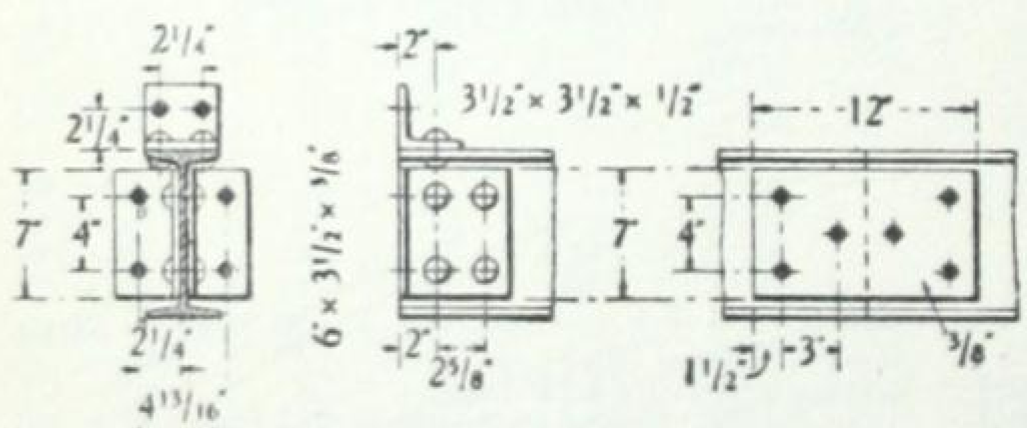
Joist	6″ × 4½″	6″ × 5″
Weight per foot (Lb.)	20	25
Web thickness (Ins.)	·37	·41
Hole Centres *a*	2-1/2″	2-3/4″
„ „ *c*	4-7/8″	4-15/16″
Flange Cleats: Weight each (Lb.)	4·12	4·58

Rivets and Bolts, 3/4″ diam.
Web Cleats: Safe End Reaction, 3·5 tons.
„ „ Weight, 5·82 lb. per pair.
Fishplates: „ 7·65 „ „ „

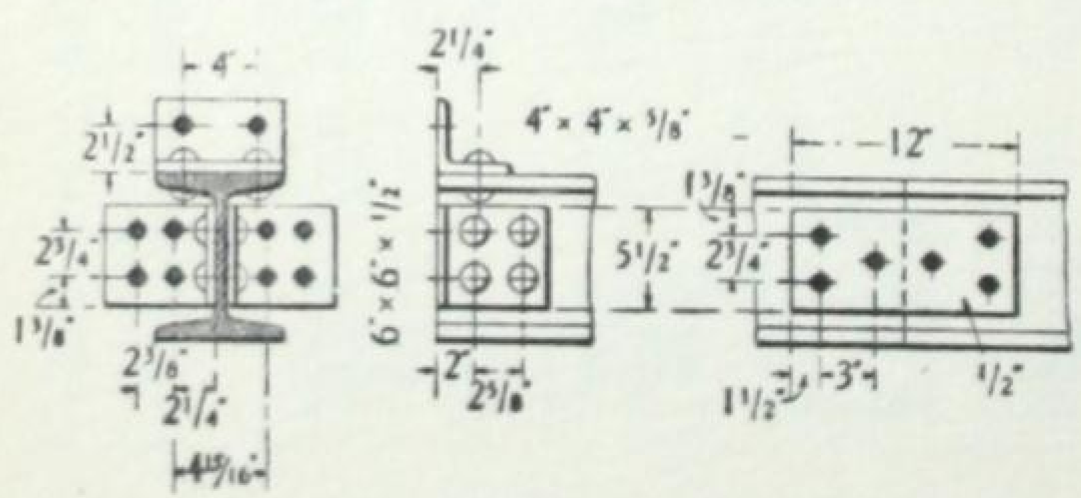


Joist	7″ × 4″	8″ × 4″	8″ × 5″	8″ × 6″
Weight per foot (Lb.)	16	18	28	35
Web thickness (Ins.)	·25	·28	·35	·35
Hole Centres *a* ...	2-1/4″	2-1/4″	2-3/4″	3-1/2″
„ „ *c* ...	4-3/4″	4-3/4″	4-7/8″	4-7/8″
Flange Cleats: Weight each, in Lb. ...	3·67	3·67	4·58	5·50

Rivets and Bolts, 3/4″ diam., but in 4″ Flange 5/8″ diam.
Web Cleats: Safe End Reaction, 7·1 tons.
„ „ Weight, 9·69 lb. per pair.
Fishplates: „ 12·75 „ „ „



Joist ... ... 9″ × 4″ × 21 lb.
Web thickness (Ins.) ... ... ·30
Rivets and Bolts: In Web, 3/4″ diam.; in Flanges, 5/8″ diam.
Web Cleats: Safe End Reaction, 7·1 tons.
„ „ Weight, 13·6 lb. per pair.
Fishplates: „ 17·8 „ „ „
Flange Cleats: „ 3·67 „ each.



Joist ... ... 9″ × 7″ × 50 lb.
Web thickness (Ins.) ... ... ·40
Rivets and Bolts, 7/8″ diam.
Web Cleats: Safe End Reaction, 19 tons.
„ „ Weight, 17·9 lb. per pair.
Fishplates: „ 18·7 „ „ „
Flange Cleats: „ 9·16 „ each.

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch. Value of flange cleats ignored.

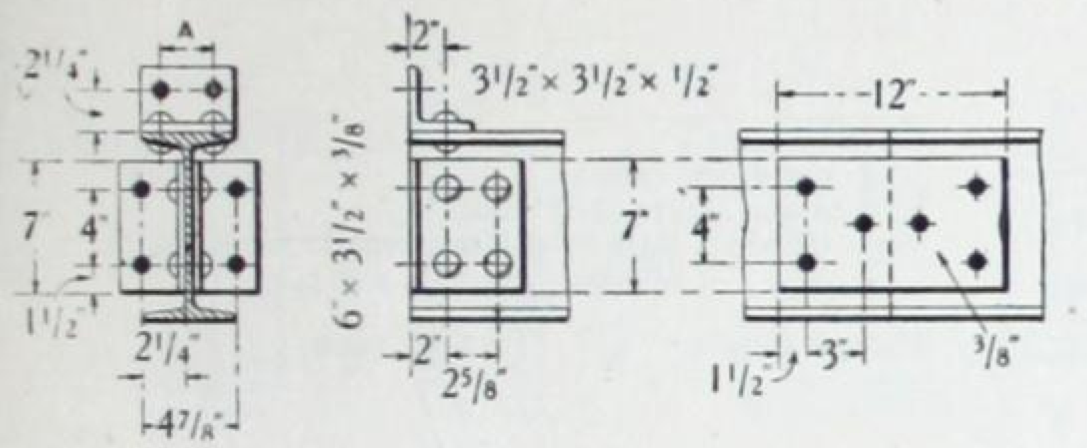
CLEARANCES. Cleats are usually made to project about 1/16″ beyond the cut ends, and about 1/4″ is usually allowed between fish-plated ends.

WEIGHTS. The weights given for fishplates and web cleats are before drilling and do not include bolts or rivets.

BRITISH STANDARD JOISTS.

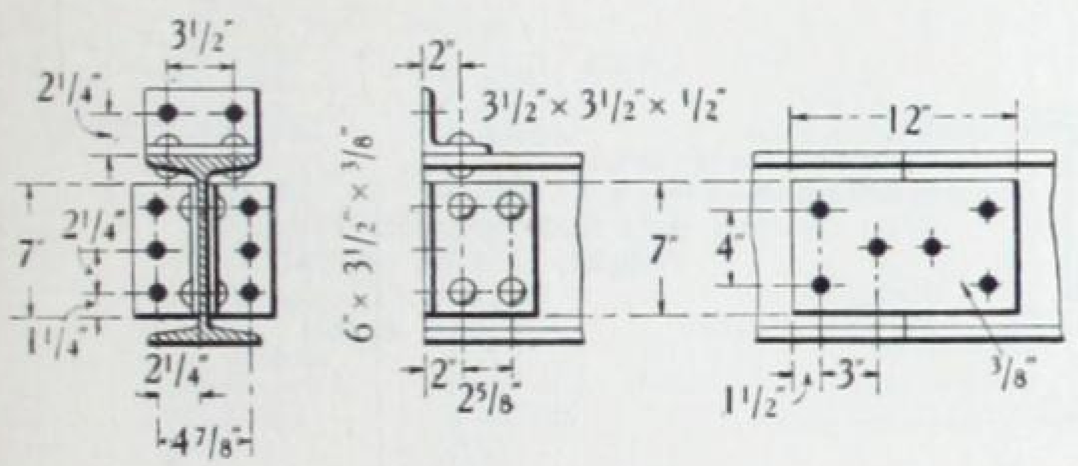
STANDARD GIRDER CONNECTIONS.—Continued.

Properties, page 172.

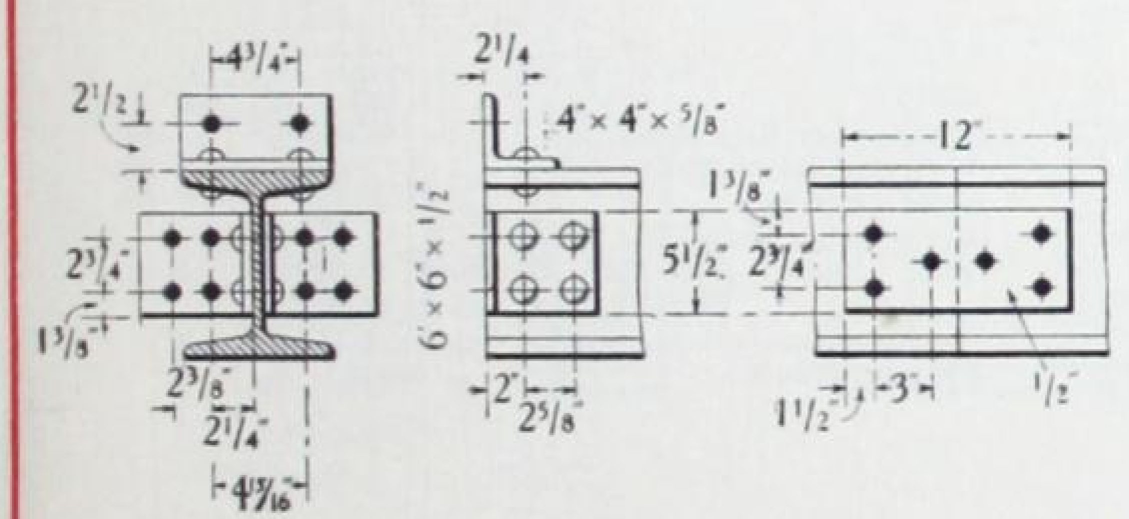


Joist ...	10" × 4½"	10" × 5"
Weight per foot (Lb.) ...	25	30
Web thickness (Ins.) ...	·30	·36
Hole Centres *a* ...	2-1/2"	2-3/4"
Flange Cleats: Weight each (Lb.)	4·12	4·58

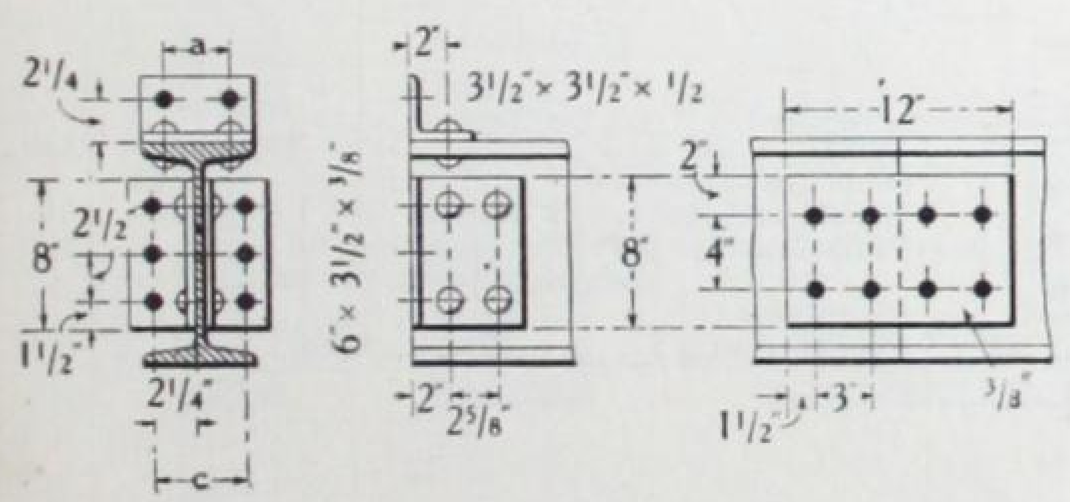
Rivets and Bolts, 3/4" diam.
Web Cleats: Safe End Reaction, 7·1 tons.
" " Weight, 13·6 lb. per pair.
Fishplates: " 17·8 " " "



Joist ... ... 10" × 6" × 40 lb.
Web thickness (Ins.) ... ... ·36
Rivets and Bolts, 3/4" diam.
Web Cleats: Safe End Reaction, 11 tons.
" " Weight, 13·6 lb. per pair.
Fishplates: " 17·8 " " "
Flange Cleats: " 5·50 " each.



Joist ... ... 10" × 8" × 55 lb.
Web thickness (Ins.) ... ... ·40
Rivets and Bolts, 7/8" diam.
Web Cleats: Safe End Reaction, 19 tons.
" " Weight, 17·9 lb. per pair.
Fishplates: " 18·7 " " "
Flange Cleats: " 10·5 " each.



Joist ...	12" × 5"	12" × 6"	12" × 6"
Weight per foot (Lb.) ...	32	44	54
Web thickness (Ins.) ...	·35	·40	·50
Hole Centres *a* ...	2-3/4"	3-1/2"	3-1/2"
" " *c* ...	4-7/8"	4-7/8"	5"
Flange Cleats: Weight each (Lb.)	4·58	5·50	5·50

Rivets and Bolts, 3/4" diam.
Web Cleats: Safe End Reaction, 11 tons.
" " Weight, 15·5 lb. per pair.
Fishplates: 20·4 " "

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch. Value of flange cleats ignored.

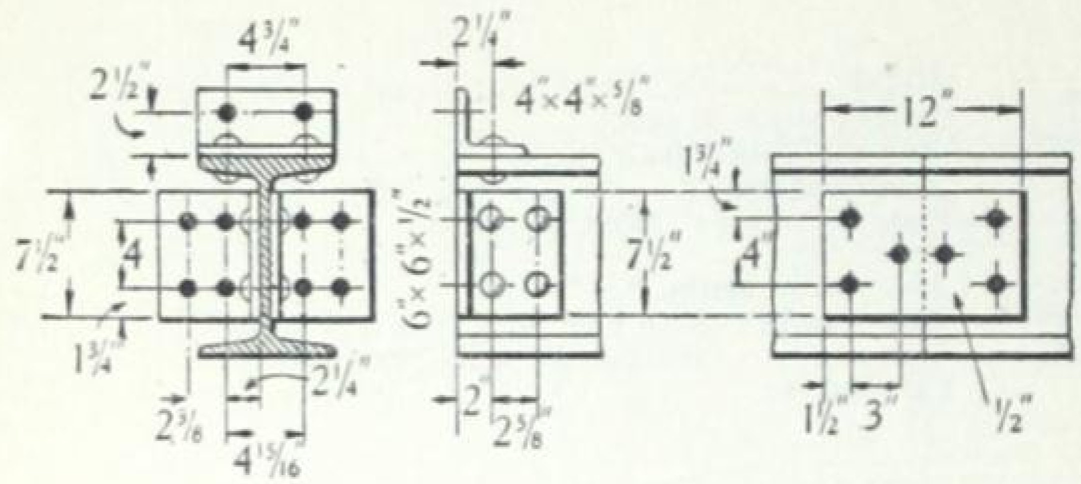
CLEARANCES. Cleats are usually made to project about 1/16" beyond the cut ends, and about 1/4" is usually allowed between fish-plated ends.

WEIGHTS. The weights given for fishplates and web cleats are before drilling and do not include bolts or rivets.

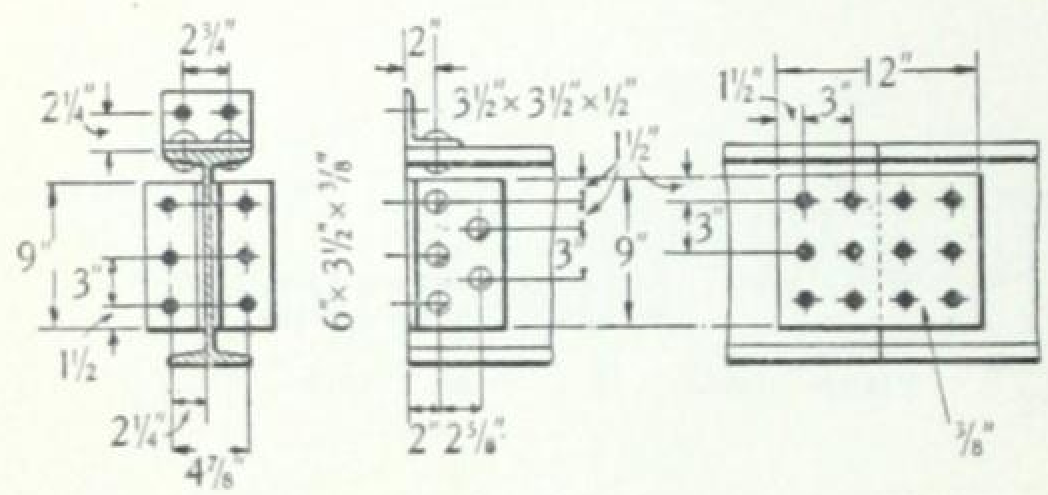
BRITISH STANDARD JOISTS.

STANDARD GIRDER CONNECTIONS.—Continued.

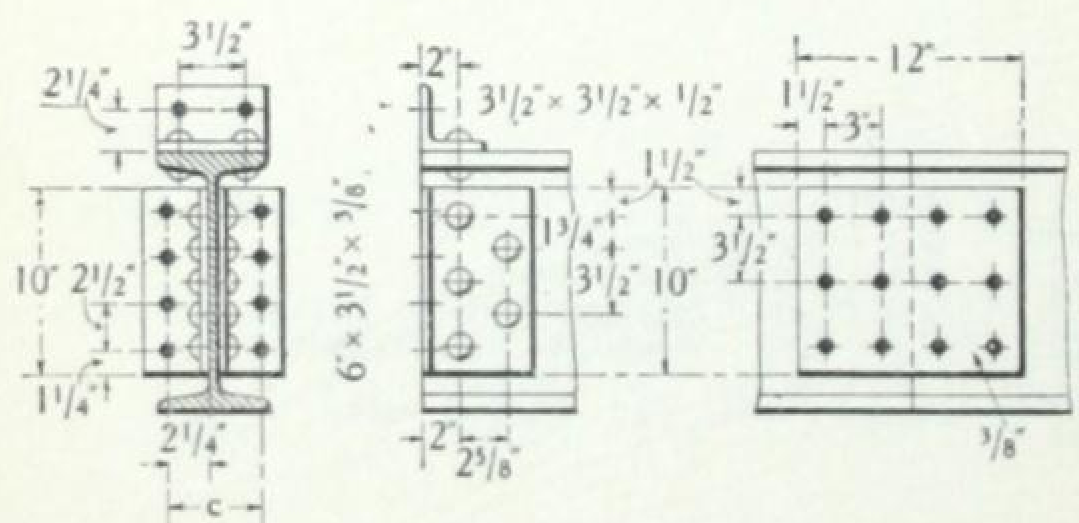
Properties, page 172



Joist ... ... 12" × 8" × 65 lb.
Web thickness (Ins.) ... ... ·43
Rivets and Bolts, 7/8" diam.
Web Cleats : Safe End Reaction, 19 tons.
,, ,, Weight, 24·5 lb. per pair.
Fishplates : ,, 25·5 ,, ,, ,,
Flange Cleats : ,, 10·5 ,, each.

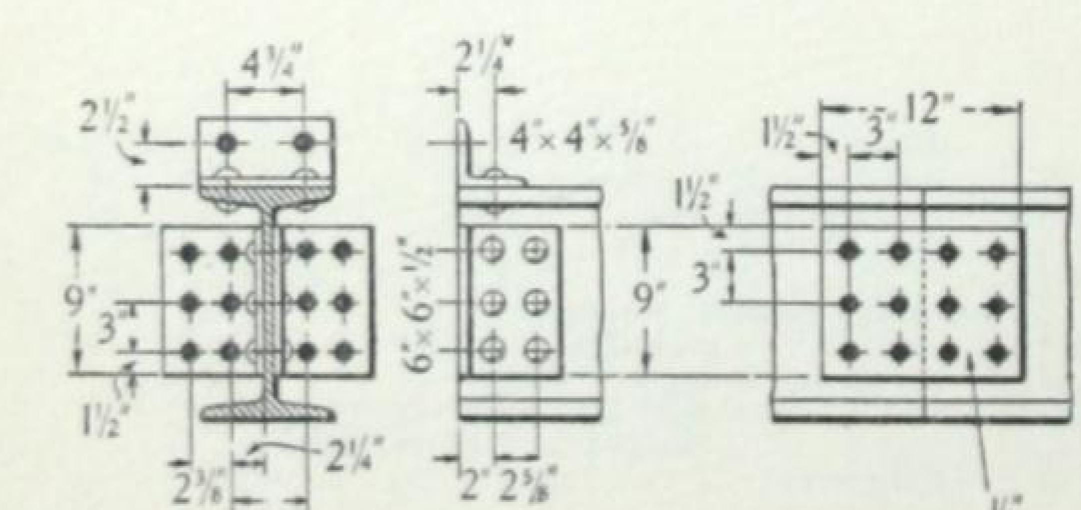


Joist ... ... 13" × 5" × 35 lb.
Web thickness (Ins.) ... ... ·35
Rivets and Bolts, 3/4" diam.
Web Cleats : Safe End Reaction, 11 tons.
,, ,, Weight, 17·4 lb. per pair.
Fishplates : ,, 22·9 ,, ,, ,,
Flange Cleats : ,, 4·6 ,, each.



Joist	14" × 6"	14" × 6"
Weight per foot (Lb.)	46	57
Web thickness (Ins.)	·40	·50
Hole Centres c	4-7/8"	5"

Rivets and Bolts, 3/4" diam.
Web Cleats : Safe End Reaction, 14 tons.
,, ,, Weight, 19·4 lb. per pair.
Fishplates : ,, 25·5 ,, ,, ,,
Flange Cleats : ,, 5·5 ,, each.



Joist ... ... 14" × 8" × 70 lb.
Web thickness (Ins.) ... ... ·46
Rivets and Bolts, 7/8" diam.
Web Cleats : Safe End Reaction, 29 tons.
,, ,, Weight, 29·4 lb. per pair.
Fishplates : ,, 30·6 ,, ,, ,,
Flange Cleats : ,, 10·5 ,, each.

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch. Value of flange cleats ignored.

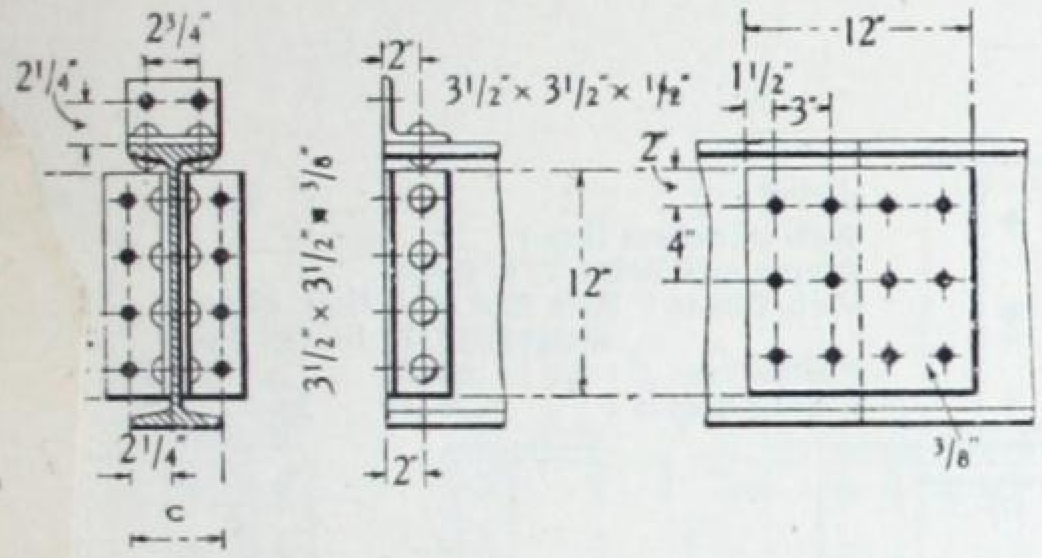
CLEARANCES. Cleats are usually made to project about 1/16" beyond the cut ends, and about 1/4" is usually allowed between fish-plated ends.

WEIGHTS. The weights given for fishplates and web cleats are before drilling and do not include bolts or rivets.

BRITISH STANDARD JOISTS.

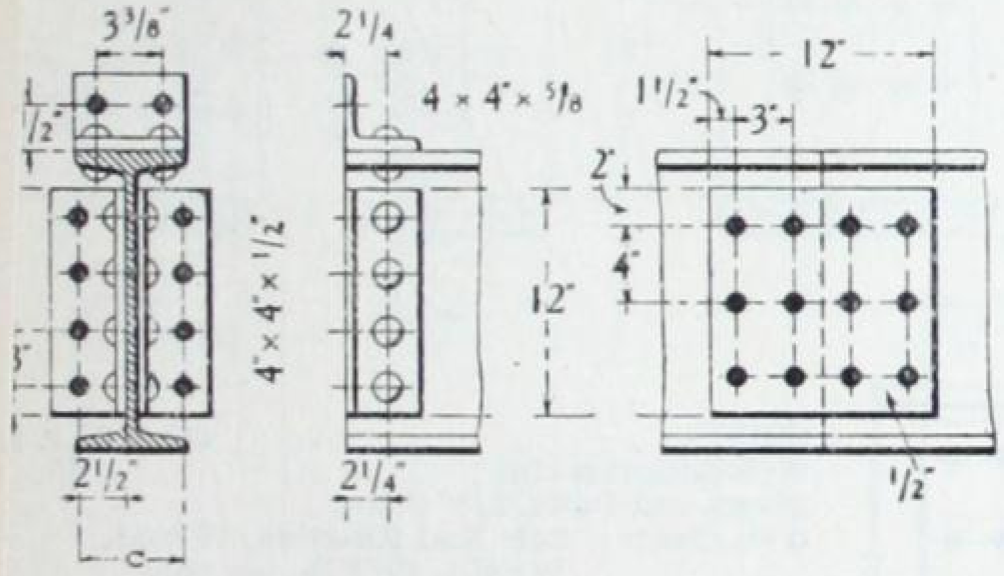
STANDARD GIRDER CONNECTIONS.—Continued.

Properties, page 172.



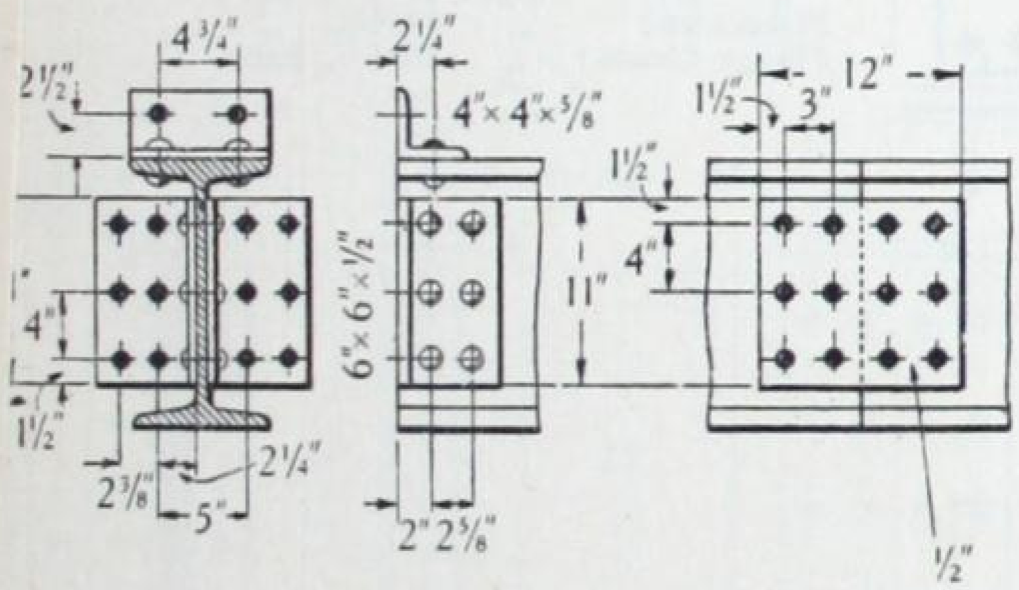
Joist	15″ × 5″	15″ × 6″
Weight per foot (Lb.)	42	45
Web thickness (Ins.)	·42	·38
Hole Centres *c*	4-15/16″	4-7/8″
Flange Cleats : Weight each (Lb.)	4·58	5·50

Rivets and Bolts, 3/4″ diam.
Web Cleats : Safe End Reaction, 14 tons.
,, ,, Weight, 16·9 lb. per pair.
Fishplates : ,, 30·6 ,, ,, ,,

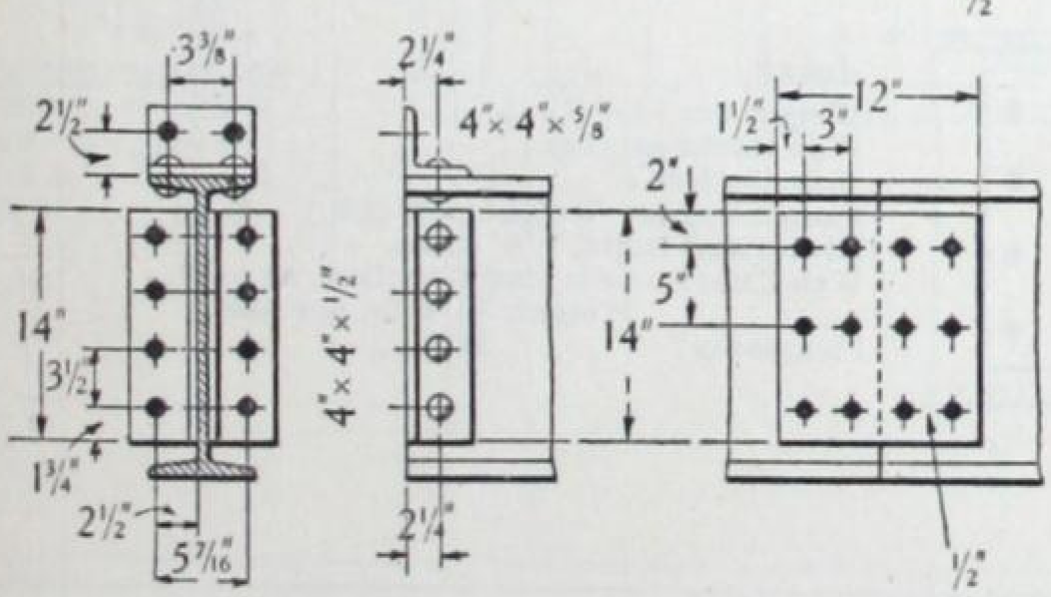


Joist	16″ × 6″	16″ × 6″
Weight per foot (Lb.)	50	62
Web thickness (Ins.)	·40	·55
Hole Centres *c*	5-7/16″	5-9/16″

Rivets and Bolts, 7/8″ diam.
Web Cleats : Safe End Reaction, 19 tons.
,, ,, Weight, 25·5 lb. per pair.
Fishplates : ,, 40·8 ,, ,, ,,
Flange Cleats : ,, 7·85 ,, each.



Joist ... ... 16″ × 8″ × 75 lb.
Web thickness (Ins.) ... ... ·48
Rivets and Bolts, 7/8″ diam.
Web Cleats : Safe End Reaction, 29 tons.
,, ,, Weight, 35·9 lb. per pair.
Fishplates : ,, 37·4 ,, ,, ,,
Flange Cleats : ,, 10·5 ,, each.



Joist ... ... 18″ × 6″ × 55 lb.
Web thickness (Ins.) ... ... ·42
Rivets and Bolts, 7/8″ diam.
Web Cleats : Safe End Reaction, 19 tons.
,, ,, Weight, 29·7 lb. per pair.
Fishplates : ,, 47·6 ,, ,, ,,
Flange Cleats : ,, 7·85 ,, each.

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch. Value of flange cleats ignored.

CLEARANCES. Cleats are usually made to project about 1/16″ beyond the cut ends, and about 1/4″ is usually allowed between fish-plated ends.

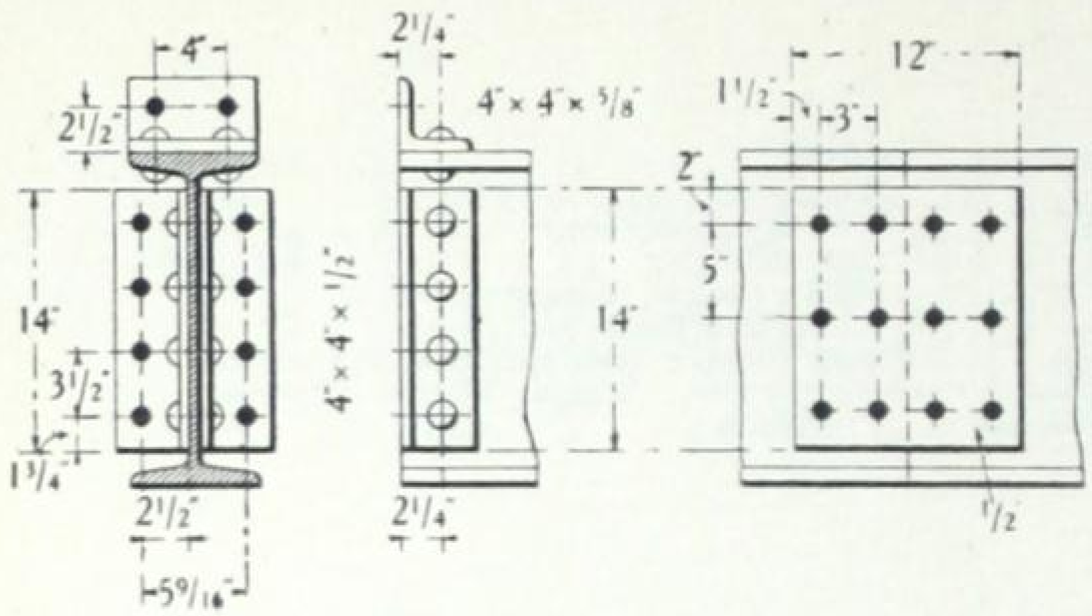
WEIGHTS. The weights given for fishplates and web cleats are before drilling and do not include bolts or rivets.

Column Loads. Column Notes. Caps, Bases. Poles, Piles. I [● ‹T Rivets, Bolts. Roofs, Concrete. Welding. Plates, Inertia. Tests, Extras. Weights, Measures. Math. tables. Index, Code.

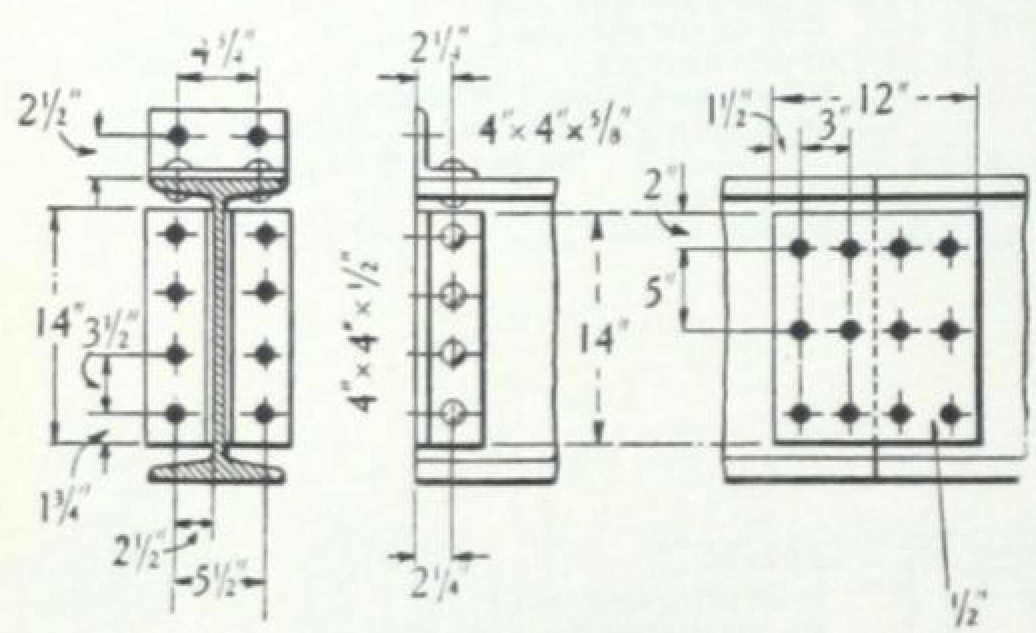
BRITISH STANDARD JOISTS.

STANDARD GIRDER CONNECTIONS.—Continued.

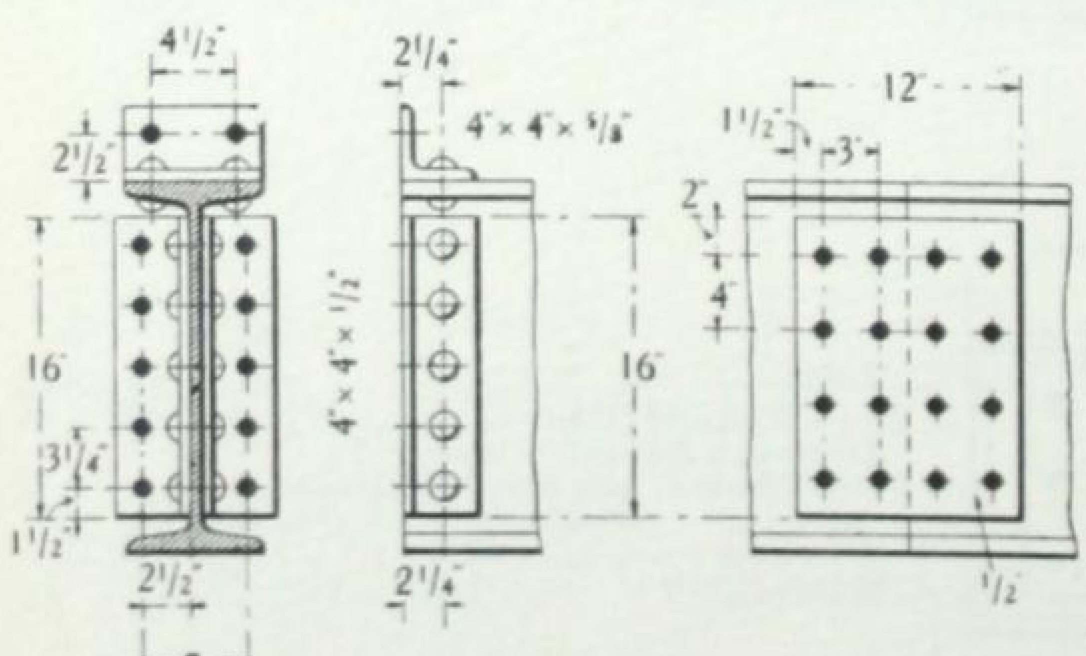
Properties, page 172.



Joist ... ... 18" × 7" × 75 lb
Web thickness (Ins.) ... ... ·55
Rivets and Bolts, 7/8" diam.
Web Cleats : Safe End Reaction, 19 tons.
" " Weight, 29·7 lb. per pair.
Fishplates : " 47·6 " " "
Flange Cleats : " 9·16 " each."



Joist ... ... 18" × 8" × 80 lb.
Web thickness (Ins.) ... ... ·50
Rivets and Bolts, 7/8" diam.
Web Cleats : Safe End Reaction, 19 tons.
" " Weight, 29·7 lb. per pair.
Fishplates : " 47·6 " " "
Flange Cleats : " 10·5 " each."



Joist	20" × 6½"	20" × 7½"
Weight per foot (Lb.)	65	89
Web thickness (Ins.)	·45	·60
Hole Centres *c*	5-7/16"	5-5/8"
Flange Cleats : Weight each (Lb.)	8·50	9·81

Rivets and Bolts, 7/8" diam.
Web Cleats : Safe End Reaction, 24 tons.
" " Weight, 34·0 lb. per pair.
Fishplates : " 54·4 " "

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch. Value of flange cleats ignored.

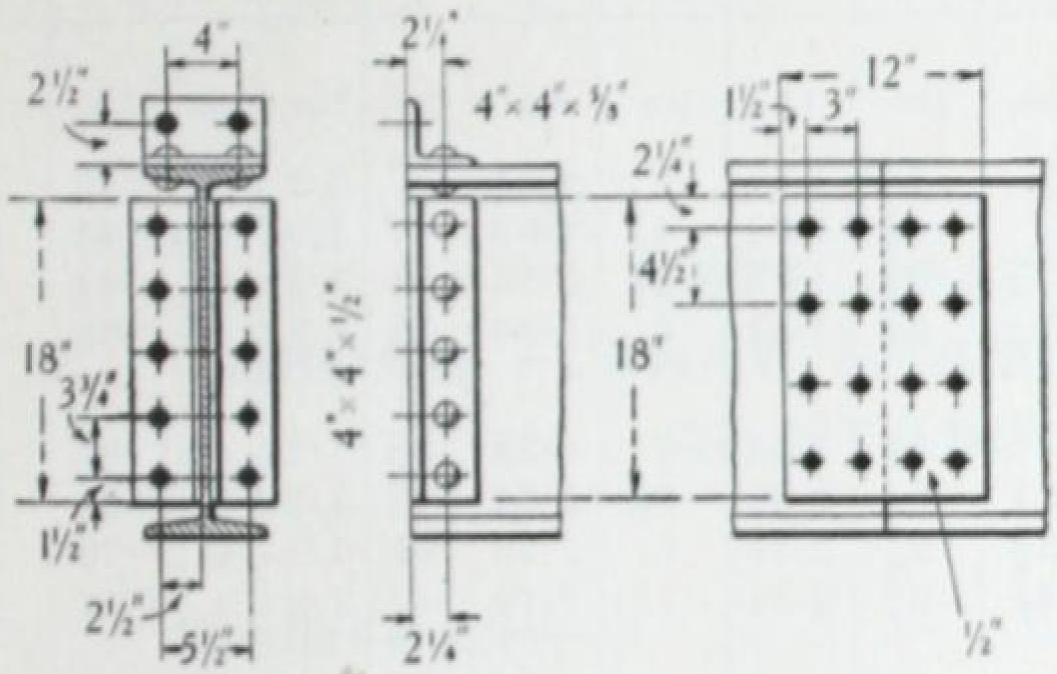
CLEARANCES. Cleats are usually made to project about 1/16" beyond the cut ends, and about 1/4" is usually allowed between fish-plated ends.

WEIGHTS. The weights given for fishplates and web cleats are before drilling and do not include bolts or rivets.

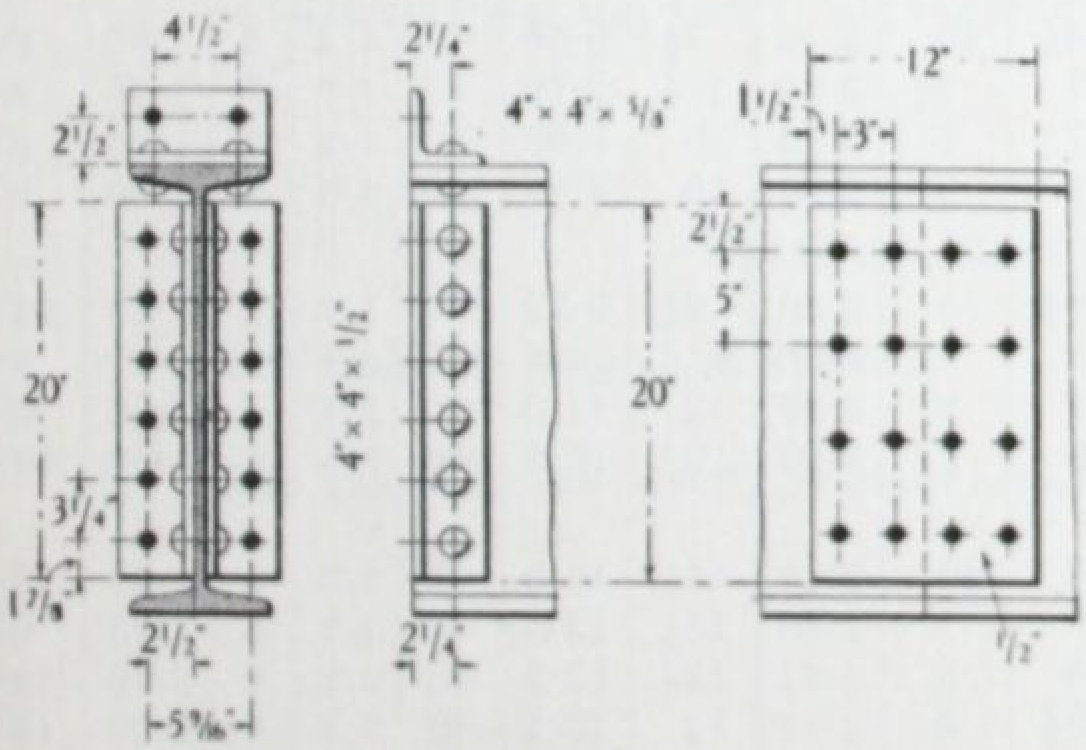
BRITISH STANDARD JOISTS.

STANDARD GIRDER CONNECTIONS.—Continued.

Properties, page 172.



Joist ... ... 22" × 7" × 75 lb.
Web thickness (Ins.) ... ... ·50
Rivets and Bolts, 7/8" diam.
Web Cleats: Safe End Reaction, 24 tons.
,, ,, Weight, 38·2 lb. per pair.
Fishplates: ,, 61·2 ,, ,, ,,
Flange Cleats: ,, 9·2 ,, each."



Joist ... ... 24" × 7½" × 95 lb.
Web thickness (Ins.) ... ... ·57
Rivets and Bolts, 7/8" diam.
Web Cleats: Safe End Reaction, 29 tons.
,, ,, Weight, 42·5 lb. per pair.
Fishplates: ,, 68·0 ,, ,, ,,
Flange Cleats: ,, 9·81 ,, each."

SAFE END REACTIONS. These represent the shear values of the bolts or rivets through the web cleats taken at 4 tons per square inch. Value of flange cleats ignored.

CLEARANCES. Cleats are usually made to project about 1/16" beyond the cut ends, and about 1/4" is usually allowed between fish-plated ends.

WEIGHTS. The weights given for fishplates and web cleats are before drilling and do not include bolts or rivets.

CAST IRON SEPARATORS,

FOR BRITISH STANDARD JOISTS.

For Notes and Illustrations, see page 74.

Joists.				Overall Width.		Bolts.				Separators.						
										Depth.						
Size.	Weight per Foot.	Web Thickness.	Centres of Webs.	2 Joists.	3 Joists.	Diameter.	Vertical Centres.	Length.	Weight of two.	of Separator.	of Web.	Corner Radii.	Thickness.	Breadth.	Weight per 1" width.	Weight of one.
Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Lb.	Lb.
6 × 3	12	·23	3·23	6·23	9·46	5/8	2	4½	1·34	5	4·41	·37	3/8	3	·48	2·5
6 × 4½	20	·37	4·87	9·37	14·24	5/8	2	6¼	1·64	4½	4·03	·47	3/8	4½	·44	3·0
6 × 5	25	·41	5·41	10·41	15·82	5/8	2	6¾	1·73	4½	3·75	·51	3/8	5	·44	3·2
7 × 4	16	·25	4·25	8·25	12·50	5/8	3	5½	1·51	6	5·36	·35	3/8	4	·58	3·4
8 × 4	18	·28	4·28	8·28	12·56	3/4	4	5¾	2·34	7	6·28	·38	1/2	4	·91	4·8
8 × 5	28	·35	5·35	10·35	15·70	3/4	3½	6¾	2·59	6½	5·74	·45	1/2	5	·84	5·4
8 × 6	35	·35	6·35	12·35	18·70	3/4	3½	7¾	2·84	6	5·25	·61	1/2	6	·76	5·7
9 × 4	21	·30	4·30	8·30	12·60	3/4	4½	5¾	2·34	7¾	7·12	·40	1/2	4	1·01	5·2
9 × 7	50	·40	7·40	14·40	21·80	3/4	3½	9	3·15	6½	5·69	·69	1/2	7	·84	7·0
10 × 4½	25	·30	4·80	9·30	14·10	3/4	5½	6¼	2·46	8½	7·84	·49	1/2	4½	1·10	6·1
10 × 5	30	·36	5·36	10·36	15·72	3/4	5½	6¾	2·59	8½	7·77	·46	1/2	5	1·10	6·7
10 × 6	40	·36	6·36	12·36	18·72	3/4	5	7¾	2·84	8	7·13	·61	1/2	6	1·04	7·4
10 × 8	55	·40	8·40	16·40	24·80	3/4	4½	10	3·40	7½	6·56	·77	1/2	8	·97	8·9
12 × 5	32	·35	5·35	10·35	15·70	3/4	7	6¾	2·59	10½	9·79	·45	1/2	5	1·36	8·0
12 × 6	44	·40	6·40	12·40	18·80	3/4	7	8	2·90	10	9·30	·50	1/2	6	1·30	8·9
12 × 6	54	·50	6·50	12·50	19·00	3/4	7	8	2·90	10	8·80	·60	1/2	6	1·30	8·9
12 × 8	65	·43	8·43	16·43	24·86	3/4	6½	10	3·40	9½	8·32	·77	1/2	8	1·23	11·0
13 × 5	35	·35	5·35	10·35	15·70	3/4	8	6¾	2·59	11½	10·5	·53	1/2	5	1·49	8·6
14 × 6	46	·40	6·40	12·40	18·80	3/4	9	8	2·90	12	11·3	·50	1/2	6	1·56	10·5
14 × 6	57	·50	6·50	12·50	19·00	3/4	9	8	2·90	12	10·8	·60	1/2	6	1·56	10·5
14 × 8	70	·46	8·46	16·46	24·92	3/4	8	10	3·40	11½	10·3	·77	1/2	8	1·49	13·1
15 × 5	42	·42	5·42	10·42	15·84	3/4	10	7	2·65	13½	12·5	·52	1/2	5	1·75	9·9
15 × 6	45	·38	6·38	12·38	18·76	7/8	10	8	4·11	13½	12·2	·61	5/8	6	2·19	14·4
16 × 6	50	·40	6·40	12·40	18·80	7/8	10½	8	4·11	14	13·1	·61	5/8	6	2·27	14·9
16 × 6	62	·55	6·55	12·55	19·10	7/8	10½	8¼	4·19	14	12·8	·65	5/8	6	2·27	14·9
16 × 8	75	·48	8·48	16·48	24·96	7/8	10	10¼	4·87	13½	12·3	·77	5/8	8	2·19	18·8
18 × 6	55	·42	6·42	12·42	18·84	7/8	12½	8	4·11	16	15·0	·61	5/8	6	2·60	16·9
18 × 7	75	·55	7·55	14·55	22·10	7/8	12	9¼	4·55	15½	14·6	·65	5/8	7	2·52	18·9
18 × 8	80	·50	8·50	16·50	25·00	7/8	12	10¼	4·87	15¼	14·2	·77	5/8	8	2·48	21·1
20 × 6½	65	·45	6·95	13·45	20·40	7/8	13½	8¾	4·36	17½	16·8	·65	5/8	6½	2·84	18·3
20 × 7½	89	·60	8·10	15·60	23·70	7/8	13	10	4·79	17	16·3	·70	5/8	7½	2·76	22·0
22 × 7	75	·50	7·50	14·50	22·00	7/8	15½	9¼	4·53	20	18·7	·69	5/8	7	3·25	24·0
24 × 7½	95	·57	8·07	15·57	23·07	7/8	17	9½	4·62	21	20·2	·73	5/8	7½	3·41	26·8

SAFE LOADS FOR BROAD FLANGE BEAMS, GREY PROCESS, AS STANCHIONS

N.B.—See next three chapters for General Notes on Stanchions, Caps and Bases, Poles and Piles. For working stresses, see page 95.

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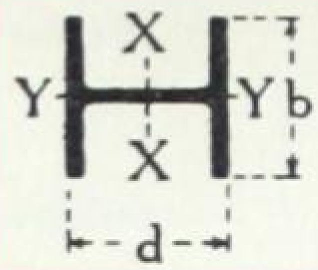


B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA.

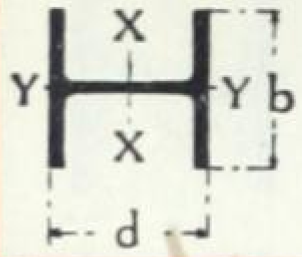
For Notes, see page 90.

Nominal Size.	Weight per Foot.	Delivery.	Radii of Gyration.		Bending Moment Multipliers.		Eccentric Load Multipliers.		Area.	$\frac{12}{g_y}$	SAFE LOADS.		
d × b			g_x	g_y	XX	YY	Flange.	Web.	A		8 ft.	9 ft.	10 ft.
Ins.	Lb.		Ins.	Ins.					Ins.²		Tons.	Tons.	Tons.
4 × 4	11·0	*a*	1·56	0·98	·76	2·03	2·41	1·20	3·22	12·2	13	11	9·1
	14·2	*a*	1·65	1·03	·72	1·86	2·43	1·19	4·18	11·7	17	15	13
	14·8	*a*	1·62	1·01	·75	1·93	2·48	1·25	4·36	11·9	18	15	13
	23·2	*ar*	1·74	1·06	·73	1·82	2·61	1·35	6·82	11·3	29	25	22
5 × 5	13·2	*a*	1·93	1·18	·60	1·68	2·35	1·17	3·87	10·2	19	16	14
	17·0	*a*	2·02	1·23	·58	1·56	2·36	1·16	5·01	9·76	25	22	20
	17·8	*a*	1·98	1·20	·60	1·64	2·42	1·21	5·24	10·0	26	23	20
	27·9	*ar*	2·10	1·25	·59	1·56	2·53	1·30	8·19	9·60	41	37	33
5½ × 5½	16·4	*a*	2·25	1·36	·51	1·46	2·34	1·16	4·82	8·82	26	24	21
	21·1	*a*	2·39	1·46	·48	1·29	2·33	1·12	6·21	8·22	35	32	30
	23·4	*a**	2·31	1·39	·52	1·43	2·42	1·22	6·84	8·64	37	34	31
	47·9	*ar*	2·53	1·49	·50	1·31	2·63	1·41	14·08	8·05	80	74	69
6 × 6	17·6	*a**	2·43	1·46	·47	1·36	2·33	1·15	5·16	8·22	29	27	25
	22·8	*a*	2·57	1·56	·45	1·21	2·32	1·11	6·70	7·69	39	36	34
	24·9	*a**	2·49	1·49	·48	1·34	2·40	1·21	7·33	8·06	42	39	36
	51·3	*ar*	2·71	1·59	·46	1·23	2·56	1·39	15·07	7·55	89	83	77
6¼ × 6¼	20·0	*a*	2·55	1·54	·45	1·31	2·34	1·16	5·87	7·79	34	32	29
	26·3	*a*	2·74	1·66	·42	1·14	2·32	1·11	7·75	7·23	46	44	41
	30·8	*a*	2·64	1·59	·45	1·25	2·42	1·22	9·05	7·55	53	50	46
	56·0	*ar*	2·85	1·69	·44	1·15	2·58	1·36	16·48	7·10	99	94	88
7 × 7	24·8	*a**	2·93	1·74	·40	1·16	2·35	1·15	7·28	6·90	44	42	40
	31·9	*a*	3·09	1·87	·37	1·01	2·32	1·11	9·37	6·42	59	56	53
	34·7	*a**	3·01	1·79	·39	1·10	2·39	1·19	10·20	6·70	63	60	57
	63·0	*ar*	3·20	1·88	·39	1·04	2·53	1·33	18·52	6·38	116	111	106
8 × 8	30·1	*a**	3·24	1·95	·36	1·03	2·34	1·14	8·84	6·15	56	54	51
	38·0	*a*	3·44	2·07	·33	·92	2·31	1·11	11·18	5·80	72	69	67
	43·6	*a**	3·34	2·00	·35	·98	2·39	1·19	12·82	6·00	82	79	76
	71·6	*ar*	3·53	2·08	·35	·94	2·50	1·30	21·06	5·77	135	131	126
8½ × 8½	34·5	*a*	3·62	2·15	·32	·92	2·31	1·13	10·15	5·58	66	64	62
	44·6	*a*	3·80	2·28	·30	·83	2·30	1·11	13·11	5·26	86	84	81
	48·0	*a**	3·70	2·20	·32	·90	2·37	1·17	14·12	5·46	92	89	86
	78·8	*ar*	3·89	2·28	·31	·86	2·48	1·27	23·17	5·27	152	148	144
9½ × 9½	40·9	*a*	3·93	2·35	·29	·84	2·31	1·13	12·02	5·11	79	77	75
	51·9	*a*	4·14	2·48	·28	·77	2·30	1·11	15·27	4·84	101	99	97
	58·7	*a*	4·03	2·40	·29	·82	2·37	1·18	17·25	4·99	114	111	109
	92·2	*ar*	4·22	2·49	·29	·78	2·47	1·26	27·11	4·82	180	176	172

B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA—Cont'd.

SAFE LOADS.															Nominal Depth
11 ft.	12 ft.	13 ft.	14 ft.	15 ft.	16 ft.	17 ft.	18 ft.	19 ft.	20 ft.	22 ft.	24 ft.	28 ft.	32 ft.	36 ft.	
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Ins.
7·9	6·7	5·8	...	...	...	...	...	...	...	...	...	...	...	...	
11	9·6	8·2	7·3	...	...	...	...	...	...	...	...	...	...	...	
11	9·7	8·4	7·3	6·7	5·7	...	...	...	...	...	...	...	...	...	4
19	17	14	12	11	...	...	...	...	...	...	...	...	...	...	
12	11	9·8	8·6	7·5	6·8	6·1	5·6	4·9	...	...	...	...	...	...	
17	15	13·5	12	10·6	9·4	8·4	7·7	7·0	6·3	...	...	...	...	...	
17	15	13·6	12	10·5	9·4	8·4	7·9	6·8	6·3	...	...	...	...	...	5
29	25	23	20	18	16	14	13	12	10	...	...	...	...	...	
19	17	15	13	12	11	9·6	8·8	7·9	7·4	6·1	...	...	...	...	
27	24	21	19	17	16	14	13	12	11	9·2	7·6	...	...	...	
28	25	22	20	18	16	14	13	12	11	8·9	...	...	...	...	5½
62	56	50	45	41	37	34	30	27	25	22	18	...	...	...	
22	20	18	16	14	13	12	11	9·7	8·8	7·6	6·3	...	...	...	
31	28	25	23	21	19	17	16	14	13	11	9·4	...	...	...	
32	29	26	23	21	19	18	16	14	13	11	9·3	...	...	...	6
71	64	59	53	48	43	40	36	33	30	25	22	...	...	...	
27	24	22	20	18	16	15	13	12	11	9·3	8·0	...	...	...	
38	35	32	29	26	24	22	20	18	17	14	12	...	...	...	
43	39	35	32	29	26	24	22	20	18	...	...	...	...	...	6½
82	76	69	63	57	52	47	44	40	37	31	26	20	...	...	
37	34	31	29	26	24	22	20	19	17	14	12	9·2	...	...	
50	47	44	40	37	34	31	29	27	25	21	18	14	...	...	
53	50	46	42	38	35	32	29	27	25	21	18	14	...	...	7
100	94	87	80	74	68	62	57	53	49	42	36	28	...	...	
49	46	43	40	37	34	32	29	27	25	22	18	14	11	...	
64	61	57	54	50	47	43	40	37	34	30	26	20	16	...	
72	68	64	60	55	51	47	44	40	37	33	28	21	16	...	8
120	115	108	102	95	88	82	76	70	65	57	49	37	30	...	
59	56	54	51	47	44	41	38	36	33	29	25	19	15	...	
78	75	72	68	65	61	57	53	50	46	40	36	27	21	17	
83	79	76	72	68	63	59	55	51	47	41	37	28	22	18	8½
139	133	127	121	115	108	100	94	88	82	71	63	48	38	30	
73	70	67	64	61	58	54	50	47	44	39	34	27	21	17	
94	91	88	84	80	77	73	68	64	60	53	47	37	29	24	
105	102	97	93	89	85	79	74	70	66	57	50	40	31	26	9½
168	162	156	150	143	137	130	122	114	108	95	83	66	52	42	



B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA.

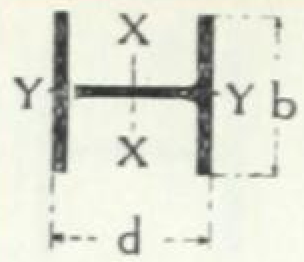
For Notes, see page 90.

Nominal Size.	Weight per Foot.	Delivery.	Radii of Gyration.		Bending Moment Multipliers.		Eccentric Load Multipliers.		Area.	$\frac{12}{g_y}$	SAFE LOADS.		
d × b			g_x	g_y	XX	YY	Flange.	Web.	A		8 ft.	9 ft.	10 ft.
Ins.	Lb.		Ins.	Ins.					Ins.²		Tons.	Tons.	Tons.
10 × 10	44·2	a*	4·12	2·46	·28	·80	2·30	1·12	12·99	4·88	86	84	82
	55·6	a	4·32	2·59	·26	·73	2·30	1·11	16·36	4·63	109	107	105
	61·1	a*	4·24	2·50	·28	·78	2·36	1·17	17·98	4·79	120	117	114
	103	ar	4·43	2·60	·27	·75	2·48	1·27	30·26	4·62	202	198	194
10½ × 10½	46·0	a	4·31	2·56	·26	·77	2·29	1·12	13·52	4·69	90	88	86
	59·5	a	4·50	2·69	·25	·71	2·29	1·11	17·50	4·46	118	115	113
	63·6	a	4·40	2·60	·27	·76	2·35	1·16	18·71	4·61	125	123	120
	116	ar	4·64	2·71	·26	·72	2·49	1·28	34·02	4·43	229	224	220
11 × 11	51·4	a	4·61	2·76	·25	·72	2·30	1·11	15·09	4·35	102	100	98
	67·7	a	4·85	2·89	·23	·66	2·29	1·11	19·92	4·15	135	133	130
	75·7	a*	4·73	2·81	·25	·70	2·36	1·16	22·26	4·27	151	148	145
	135	ar	5·00	2·93	·24	·66	2·49	1·28	39·60	4·10	270	265	260
12 × 12	58·9	a*	4·99	2·96	·23	·67	2·30	1·12	17·31	4·05	118	116	114
	76·4	a	5·20	3·10	·22	·61	2·29	1·10	22·46	3·87	154	152	149
	81·2	a*	5·09	3·01	·23	·65	2·35	1·15	23·87	3·99	163	160	158
	158	ar	5·42	3·15	·23	·62	2·49	1·28	46·34	3·81	319	314	309
12½ × 12	65·8	a	5·30	2·95	·22	·67	2·30	1·12	19·33	4·07	132	130	127
	81·4	a	5·53	3·08	·21	·62	2·29	1·11	23·94	3·90	164	162	159
	90·3	a	5·40	2·99	·22	·66	2·36	1·17	26·55	4·01	182	178	175
	166	ar	5·74	3·13	·21	·62	2·49	1·28	48·81	3·83	336	330	325
13½ × 12	70·7	a	5·65	2·93	·20	·68	2·32	1·13	20·77	4·10	142	139	136
	86·2	a	5·85	3·06	·20	·63	2·31	1·12	25·35	3·92	174	171	168
	91·6	a	5·74	2·97	·20	·67	2·36	1·17	26·95	4·04	184	181	178
	168	ar	6·07	3·11	·20	·63	2·43	1·29	49·53	3·86	340	335	329
14 × 12	75·7	a	5·93	2·91	·19	·69	2·33	1·14	22·24	4·12	151	149	146
	91·3	a	6·18	3·04	·19	·64	2·31	1·12	26·84	3·95	184	181	177
	101	a*	6·04	2·96	·19	·68	2·38	1·19	29·68	4·05	203	199	195
	170	ar	6·34	3·08	·19	·64	2·48	1·29	50·03	3·90	343	338	332
15 × 12	80·6	b	6·29	2·90	·18	·70	2·35	1·15	23·74	4·14	162	159	156
	96·3	b	6·51	3·03	·18	·64	2·32	1·13	28·31	3·96	194	191	187
	102	b	6·38	2·94	·18	·68	2·38	1·19	30·12	4·08	205	202	198
	172	br	6·67	3·06	·18	·65	2·48	1·30	50·74	3·93	348	342	336
16 × 12	84·9	a	6·60	2·90	·18	·70	2·34	1·15	24·93	4·14	170	167	164
	101	a	6·83	3·01	·17	·65	2·33	1·14	29·81	3·99	204	200	197
	110	a	6·71	2·95	·17	·68	2·38	1·19	32·32	4·07	220	217	213
	172	ar	6·95	3·04	·17	·66	2·47	1·29	50·65	3·94	347	341	335

B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA.—Cont'd.

SAFE LOADS.															Nominal Depth.
11 ft.	12 ft.	13 ft.	14 ft.	15 ft.	16 ft.	17 ft.	18 ft.	19 ft.	20 ft.	22 ft.	24 ft.	28 ft.	32 ft.	36 ft.	
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Ins.
80	77	74	71	68	65	61	58	54	51	45	39	31	25	20	
102	99	96	92	89	85	81	77	72	68	61	53	43	34	27	
111	108	104	100	94	91	86	81	76	72	63	56	44	35	28	10
190	184	179	171	165	158	150	143	134	126	113	99	79	63	51	
84	82	79	76	73	70	66	63	59	56	49	43	35	27	22	
111	108	105	101	97	93	89	85	81	76	68	60	48	39	31	
117	114	110	106	102	97	93	88	83	78	70	61	49	39	31	10¼
216	210	204	197	190	182	174	167	158	149	134	118	95	77	62	
96	94	91	88	85	82	79	75	72	68	61	54	43	35	28	
128	126	122	119	115	111	107	103	99	94	84	76	61	50	40	
142	139	135	132	127	122	117	112	108	102	91	82	65	53	43	11
255	250	244	238	231	223	215	206	198	190	170	154	123	102	82	
112	110	107	104	101	98	94	91	87	84	75	68	55	45	37	
146	144	141	138	134	130	126	122	117	113	103	93	76	62	52	
155	152	149	145	141	136	132	127	122	117	106	96	77	64	52	12
303	298	292	286	278	271	262	253	245	236	216	196	160	132	110	
125	123	120	116	113	109	105	101	97	93	84	76	61	50	41	
156	153	150	147	143	138	134	129	124	120	109	99	80	66	55	
172	169	165	161	156	151	146	140	135	130	117	106	85	70	57	12½
319	313	308	300	293	285	275	266	257	247	226	205	167	138	115	
134	131	128	125	121	117	112	108	104	99	89	81	65	53	43	
165	162	159	155	151	146	141	136	131	126	115	104	84	69	57	
174	171	167	163	158	153	147	142	136	131	118	109	86	71	57	13½
323	317	311	304	296	288	278	268	259	250	228	206	168	138	115	
143	140	137	133	129	125	120	115	111	106	95	86	68	57	46	
174	171	168	163	159	154	149	143	138	133	121	109	88	73	60	
192	188	184	179	174	168	162	156	150	143	129	117	94	77	63	14
326	320	314	306	298	289	280	270	260	250	228	206	167	138	115	
153	150	146	142	138	133	128	123	118	112	101	91	73	60	48	
184	180	177	172	168	162	157	151	146	140	127	115	92	76	63	
194	191	186	181	176	170	164	157	151	145	130	117	94	78	63	15
330	324	318	309	302	292	282	272	262	253	229	207	168	138	115	
160	157	153	149	144	139	134	129	124	118	106	95	76	63	51	
193	190	186	181	176	170	164	158	152	146	132	120	97	80	65	
209	205	200	195	189	182	176	169	163	156	140	127	101	84	68	16
329	323	316	308	300	291	281	271	261	251	227	206	166	137	113	



B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA.

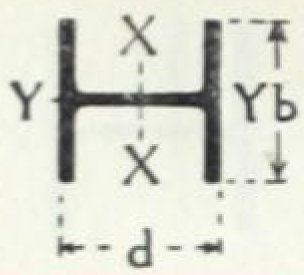
For Notes, see page 90.

Nominal Size.	Weight per Foot.	Delivery	Radii of Gyration.		Bending Moment Multipliers.		Eccentric Load Multipliers.		Area.	$\frac{12}{g_y}$	SAFE LOADS		
d × b			g_x	g_y	XX	YY	Flange.	Web.	A		8 ft.	9 ft.	10 ft.
Ins.	Lb.		Ins.	Ins.					Ins.²		Tons.	Tons.	Tons.
	90·4	*b*	7·03	2·88	·16	·71	2·34	1·16	26·57	4·17	181	177	174
	107	*b*	7·23	2·99	·16	·66	2·34	1·15	31·42	4·01	215	211	207
17 × 12	112	*b*	7·13	2·93	·16	·69	2·38	1·19	32·86	4·10	224	220	216
	175	*br*	7·36	3·02	·16	·67	2·47	1·29	51·50	3·98	353	347	340
	96·3	*a*	7·39	2·86	·16	·72	2·35	1·17	28·29	4·20	192	189	185
	113	*a*	7·63	2·97	·15	·67	2·35	1·16	33·18	4·04	227	223	219
18 × 12	122	*a*	7·51	2·91	·16	·70	2·39	1·21	35·90	4·13	244	240	236
	175	*ar*	7·73	2·99	·16	·67	2·46	1·28	51·47	4·02	352	346	340
	102	*c*	7·82	2·84	·15	·73	2·37	1·18	30·00	4·23	204	200	196
	119	*c*	8·03	2·95	·14	·68	2·36	1·17	34·86	4·07	238	234	229
19 × 12	124	*c*	7·91	2·88	·15	·71	2·40	1·21	36·48	4·16	248	243	239
	178	*cr*	8·13	2·96	·15	·69	2·46	1·29	52·29	4·05	357	350	344
	108	*a*	8·18	2·82	·14	·74	2·38	1·19	31·73	4·26	215	211	207
	125	*a*	8·43	2·93	·14	·69	2·36	1·17	36·64	4·10	250	245	241
20 × 12	135	*a*	8·29	2·87	·14	·72	2·41	1·23	39·57	4·19	269	264	259
	180	*ar*	8·47	2·93	·14	·70	2·46	1·29	52·91	4·09	361	354	348
	113	*c*	9·00	2·78	·13	·76	2·39	1·19	33·20	4·32	225	220	216
	132	*c*	9·23	2·89	·13	·71	2·38	1·19	38·92	4·15	265	260	255
22 × 12	139	*c*	9·09	2·82	·13	·74	2·42	1·23	40·81	4·25	277	271	266
	185	*cr*	9·27	2·89	·13	·72	2·46	1·30	54·54	4·15	371	364	357
	124	*b*	9·74	2·74	·12	·78	2·41	1·21	36·47	4·38	246	241	237
	141	*b*	10·00	2·85	·12	·73	2·39	1·20	41·40	4·21	281	276	271
24 × 12	152	*b*	9·85	2·78	·12	·76	2·44	1·26	44·78	4·31	303	297	291
	191	*br*	9·99	2·84	·12	·74	2·47	1·31	56·04	4·23	381	373	366
	128	*b*	10·52	2·70	·11	·80	2·42	1·22	37·55	4·44	253	248	243
26 × 12	157	*b*	10·63	2·74	·11	·79	2·45	1·26	46·10	4·38	311	305	299
	196	*br*	10·77	2·80	·11	·76	2·48	1·32	57·67	4·29	390	383	375
	141	*b*	11·26	2·67	·11	·82	2·45	1·24	41·44	4·49	279	273	267
28 × 12	171	*b*	11·37	2·71	·11	·81	2·47	1·29	50·22	4·43	338	331	325
	201	*br*	11·48	2·75	·11	·79	2·49	1·33	59·11	4·36	399	391	384
	145	*b*	12·02	2·63	·10	·85	2·47	1·25	42·61	4·56	286	280	274
30 × 12	176	*b*	12·13	2·67	·10	·83	2·48	1·29	51·62	4·49	347	340	333
	207	*br*	12·24	2·71	·10	·81	2·50	1·34	60·74	4·42	409	401	393
	159	*b*	12·81	2·61	·10	·86	2·48	1·27	46·84	4·60	314	307	301
32 × 12	180	*b*	12·89	2·64	·10	·85	2·49	1·30	53·01	4·55	356	348	341
	212	*br*	12·99	2·68	·09	·83	2·51	1·34	62·37	4·48	420	411	403

B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA.—Cont'd.

SAFE LOADS.															Nominal Depth.
11 ft.	12 ft.	13 ft.	14 ft.	15 ft.	16 ft.	17 ft.	18 ft.	19 ft.	20 ft.	22 ft.	24 ft.	28 ft.	32 ft.	36 ft.	
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Ins.
171	167	163	158	153	148	142	137	131	125	112	101	81	66	53	
204	200	195	190	185	179	172	166	160	154	139	125	101	83	68	
212	208	203	197	192	185	178	172	165	157	141	127	103	84	68	17
334	328	321	313	305	295	284	274	264	253	230	208	167	138	114	
181	178	173	168	163	157	151	145	139	132	118	106	85	70	56	
215	210	206	200	195	188	181	175	168	161	145	131	106	87	71	
231	227	221	215	208	201	194	186	179	171	153	138	111	91	73	18
334	327	320	311	303	293	283	272	262	251	227	205	165	136	111	
192	188	183	178	172	166	159	153	146	139	124	112	89	73	58	
225	221	215	210	204	197	190	183	175	168	151	137	109	90	74	
235	230	224	218	211	203	196	188	180	172	154	139	111	91	73	19
338	331	324	315	306	295	285	274	264	253	227	205	165	136	111	
203	199	193	188	183	174	167	161	154	146	131	117	93	76	61	
236	232	226	220	213	206	198	191	183	175	157	142	114	94	76	
254	249	242	236	228	220	211	203	195	185	166	150	120	99	79	20
341	334	326	318	308	297	287	276	265	253	227	205	165	136	110	
212	207	201	195	188	181	174	166	159	150	134	120	95	78	63	
250	246	239	233	225	217	209	201	193	184	165	148	119	98	78	
261	255	249	242	233	224	215	207	198	188	168	151	120	99	79	22
351	344	335	326	315	304	293	281	270	257	231	208	166	137	110	
232	226	220	213	205	197	189	181	172	162	145	129	103	84	67	
265	260	253	246	238	229	220	212	203	193	173	155	123	102	82	
285	279	271	263	253	244	234	224	214	202	181	162	129	106	85	24
359	351	342	332	321	309	298	285	274	260	233	209	166	137	110	
238	232	225	217	209	201	192	184	174	164	147	130	104	84	68	
293	286	278	269	259	248	238	229	217	205	183	163	130	106	85	26
368	360	350	340	328	316	303	291	278	263	235	211	167	138	110	
262	255	247	239	229	220	211	201	190	179	160	141	113	91	73	
318	310	301	291	280	269	258	247	234	220	197	175	140	113	91	28
376	366	356	345	332	320	307	294	280	264	236	210	167	137	110	
268	260	253	243	233	224	214	203	192	181	161	142	114	90	73	
326	317	308	297	285	274	262	250	236	222	199	176	141	113	91	30
385	375	364	352	339	326	312	298	282	266	239	211	169	137	110	
294	285	277	266	255	244	234	222	209	197	175	154	123	98	79	
334	324	315	303	291	279	272	254	240	225	201	177	142	113	92	32
394	384	372	359	346	331	317	303	286	269	241	213	171	137	111	



B.F. BEAMS, GREY PROCESS: AS STANCHIONS

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA.

Nominal Size.	Weight per Foot.	Delivery.	Radii of Gyration.		Bending Moment Multipliers.		Eccentric Load Multipliers.		Area.	$\frac{12}{g_y}$	SAFE LOADS.		
d × b			g_x	g_y	XX	YY	Flange.	Web.	A		8 ft.	9 ft.	10 ft.
Ins.	Lb.		Ins.	Ins.					Ins.²		Tons.	Tons.	Tons.
34×12	174	*c*	13·54	2·57	·09	·89	2·49	1·30	51·26	4·67	342	335	328
	196	*c*	13·61	2·61	·09	·86	2·51	1·33	57·47	4·61	385	377	369
	218	*cr*	13·66	2·63	·09	·86	2·53	1·36	63·97	4·56	429	420	411
36×12	179	*c*	14·28	2·54	·09	·91	2·51	1·30	52·58	4·72	351	343	336
	201	*c*	14·35	2·57	·09	·89	2·53	1·34	58·95	4·67	392	384	375
	223	*cr*	14·40	2·60	·09	·88	2·54	1·37	65·60	4·62	439	430	420
38×12	183	*c*	15·01	2·51	·08	·93	2·53	1·31	53·90	4·78	359	351	343
	206	*c*	15·08	2·54	·08	·91	2·54	1·34	60·42	4·72	403	394	385
	229	*cr*	15·13	2·57	·08	·90	2·55	1·37	67·23	4·67	449	440	430
40×12	188	*b*	15·74	2·48	·08	·95	2·54	1·32	55·21	4·84	367	358	350
	211	*b*	15·81	2·51	·08	·94	2·55	1·35	61·89	4·78	412	403	394
	234	*br*	15·86	2·54	·08	·92	2·57	1·38	68·85	4·73	459	449	439

1. STRESSES AND SAFE LOADS. The tabulated loads are calculated by the British Standard formula (B.S.S. 449) for hinged ends—"ends adequately restrained in position but not in direction." For the corresponding stresses, and for other conditions of ends, see page 95.

2. $12 \div g_y$. To find the l/g_y for any of the above sections, multiply the tabulated $12/g_y$ by the height in feet.

3. ZIG-ZAG LINE. Heights to the right of the zig-zag line exceed $150gy$, only permissible for subsidiary compression members in B.S.S. 449, § 15.

4. BENDING MOMENT AND ECCENTRIC LOAD MULTIPLIERS. When a stanchion is eccentrically loaded by a girder cleated to it, multiply the load by the tabulated *Eccentric Load Multiplier* (using the figures headed "Web" if the connection is to the web of the stanchion); the result is the equivalent *central* load. For other cases of bending moment—*e.g.*, from wind pressure—calculate the Bending Moment (inch-tons), and multiply it by the tabulated *Bending Moment Multiplier*. The result, added to the actual vertical load, gives the equivalent *central* load. For further explanation, see pages 96 to 100.

B.F. BEAMS, GREY PROCESS : AS STANCHIONS.

SAFE CENTRAL LOADS BY BRITISH STANDARD FORMULA—Cont'd.

SAFE LOADS.															Nominal Depth.
11 ft.	12 ft.	13 ft.	14 ft.	15 ft.	16 ft.	17 ft.	18 ft.	19 ft.	20 ft.	22 ft.	24 ft.	28 ft.	32 ft.	36 ft.	
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Ins.
320	311	301	289	277	265	253	239	224	212	188	165	132	103	84	
361	350	340	326	313	300	287	272	256	241	215	189	152	120	97	34
403	391	380	366	351	336	322	306	289	272	243	214	171	137	111	
327	317	307	294	282	269	257	242	227	215	190	167	133	104	84	
366	355	345	332	318	304	291	274	258	243	216	190	152	119	96	36
411	399	386	371	357	342	326	309	291	274	244	215	172	136	110	
334	324	312	299	286	274	260	245	230	217	191	168	134	105	85	
376	364	352	338	323	309	296	278	260	246	218	192	153	119	97	38
420	407	394	379	363	347	331	313	294	278	246	216	173	136	110	
341	330	318	304	291	278	263	247	232	219	192	169	134	105	86	
384	372	358	343	329	314	298	280	264	249	219	192	153	120	98	40
428	415	401	385	368	353	336	317	297	280	248	218	174	136	110	

5. **WEIGHTS PER FOOT.** The various weights listed for each section are :—

(i) Up to 24″ × 12″, the DIE, DIL, DIN, and DIR series respectively, as explained on page 21.

(ii) Above 24″ × 12″, the DIE, DIN, and DIR series respectively.

These are all obtainable with equal facility from the mills, except that the DIR (maximum weight) series can only be supplied in the minimum quantities tabulated on page 286 ; the weights marked with an asterisk are stocked in the United Kingdom.

6. **INTERMEDIATE WEIGHTS.** All sections can be rolled to weights intermediate between the tabulated minima and maxima, subject to the conditions explained on pages 11 and 286.

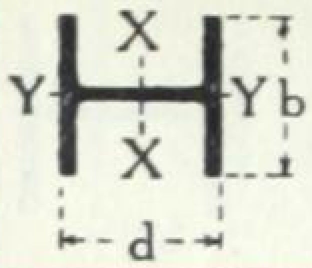
7. **DELIVERY.** The meanings of the symbols are as follows :—

(*a*) Average rolling dates 3–4 weeks.
(*b*) Average rolling dates 4–6 weeks.
(*c*) Average rolling dates 6–8 weeks.

The addition of an asterisk means stocked in the United Kingdom.

N.B.—These indications of the time required for delivery refer to normal pre-war conditions. For the present position (1948), see note at foot of page 6.

8. **DESCRIBE WHEN ORDERING** as " Broad Flange Beams, Grey Process, ...″ × ...″ × ... lb. nominal." See also page 267 (" Tests ").



EXTRA WIDE FLANGED

B.F. BEAMS, GREY PROCESS: AS STANCHIONS.

SAFE LOADS BY BRITISH STANDARD FORMULA.

Exact Size.	Weight per Foot	Section Modulus		Moment of Inertia		Radii of Gyration		Bending Moment Multipliers		Eccentric Load Multipliers		Area.	$\frac{12}{g_y}$
d × b		Z_x	Z_y	I_x	I_y	g_x	g_y	XX	YY	Flange	Web	A	
Ins.	Lb.	Ins.³	Ins.³	Ins.⁴	Ins.⁴	Ins.	Ins.					Ins.²	
3·70 × 5·12	13·6	5·4	2·75	10·1	7·0	1·59	1·33	·73	1·45	2·35	1·14	3·99	9·02
4·49 × 5·91	15·8	7·9	3·66	17·7	10·8	1·95	1·53	·59	1·26	2·32	1·12	4·64	7·84
5·24 × 6·69	19·3	11·3	5·00	29·6	16·7	2·29	1·72	·50	1·13	2·31	1·12	5·66	6·98
5·63 × 7·09	20·4	13·0	5·60	36·6	19·9	2·47	1·82	·46	1·07	2·30	1·12	6·01	6·59
5·91 × 7·48	23·1	15·3	6·61	45·3	24·7	2·58	1·91	·44	1·03	2·31	1·12	6·79	6·28
6·77 × 7·87	27·2	20·6	8·14	69·9	32·1	2·96	2·00	·39	·98	2·31	1·13	7·99	6·00
7·48 × 8·66	32·8	27·5	10·8	103	46·9	3·27	2·21	·35	·89	2·31	1·13	9·63	5·43

d × b	SAFE LOADS.												
	8 ft.	9 ft.	10 ft.	11 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	22 ft.	24 ft.	28 ft.	32 ft.
Ins.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
3·70 × 5·12	21	19	17	15	14	11	8·6	7·0	5·8	4·9	...	...	...
4·49 × 5·91	27	25	23	21	19	16	13	10	8·7	7·3	6·3	...	...
5·24 × 6·69	34	33	31	29	26	22	18	15	13	11	9·5	7·1	...
5·63 × 7·09	37	36	34	32	30	25	21	18	15	13	11	8·4	...
5·91 × 7·48	43	41	39	37	35	30	26	22	19	16	14	10	...
6·77 × 7·87	51	49	47	45	42	37	32	27	23	20	17	13	10
7·48 × 8·66	63	61	59	57	55	49	43	38	33	28	25	19	15

1. The sections tabulated above are primarily designed for use as Poles, but they also make highly efficient stanchions, as may be seen by comparing their safe loads with those of the standard sections.

The wide flanges are also eminently suitable for welded connections.

2. These sizes are obtainable (from mills) as readily as the standard sizes and without extra if ordered in quantities of at least 10 tons of a size.

NOTES ON COLUMNS

PRINTED ELSEWHERE

NOTES ON STANCHIONS.

1. TABULATED SAFE LOADS.

In the present edition, the various tables of safe loads for columns are all calculated by the British Standard formula (B.S.S. 449, 1937) : for mild steel, and for " both ends held in position but unrestrained in direction," which is equivalent to assuming hinged ends. The same stresses have been adopted in the London County Council's By-Laws (1937)*. They are tabulated on the opposite page ; and with them, for comparison, the stresses calculated by Fidler's formula for fixed ends.

2. END FIXING.

In the chapter headed "Tests, Extras" will be found notes and extracts from B.S.S. No. 449 (§16), giving definitions of end fixing and effective length. In general, if the ends of a column are not " fixed," the effect is the same as increasing the length of the column ; the following are the appropriate multipliers according to various authorities.

	Euler.	*Fidler.*	*B.S.S.*
Both ends fixed	1	1	·7
One end fixed, one hinged	1–1/3	1–1/4	·85
Both ends hinged	2	1–2/3	1
One end fixed, one free	4	3–1/3	1 to 2

The assumption of fixed ends—even with the reduced multipliers proposed by Fidler and the B.S.S.—should be made only when the conditions are exceptionally favourable, as in the bottom tier of interior stanchions in a steel frame building of moderate height, where the stanchions are connected to girders on all four sides, and the loading is symmetrical.

B.S.S. 449—1937 says that a column may generally be assumed to have its end " held in position " (hinged) when the resistance moment of the restraining member and its connections is equal to ·25 of the resistance moment of the compression member (as a beam with 8 tons per sq. inch extreme fibre stress) for values of l/g up to 120 ; or, for higher values, the resistance moment multiplied by ·25—·02 (l/g—120).

Up to a length of 120 l/g a column with a fixed, flat, or square end, so as to distribute the load uniformly over the entire area of its section, may generally be assumed to have an end connection with a moment of resistance equal to ·25 of the resistance moment of the compression member and to be effectively restrained (against crippling due to axial loading). If the length exceeds 120 l/g, the ends may generally be taken to be partially restrained.

3. CHOICE OF SECTIONS.

Where saving of space is the main consideration, the choice may be between employing girders over long spans without intermediate supports, or using solid round steel columns, despite the considerable extra cost involved.

Where economy and stability are the main considerations, the most advantageous sections for loads ranging from about 10 to 300 tons are Broad Flange Beams, Grey Process.

For smaller loads, a light rolled steel joist (e.g., 4″×3″) may suffice ; for greater loads some form of built-up stanchion will probably be required.

The economy of Broad Flange Beams, square in shape, compared with such joist sections as 6″×5″, 8″×6″, 9″×7″ and 10″×8″ is clearly shown by the following instances, the loads being calculated by the same formula (B.S.S., as employed for the various tables in this book) and for the same length, here taken as 12 feet :—

(i) R.S.J. 8″ × 6″ × 35 lb., safe load 37 tons ; B.F.B. 7·5″ × 7·8″ × 30·1 lb., safe load 46 tons.

(ii) R.S.J. 10″ × 8″ × 55 lb., safe load 81 tons ; B.F.B. 9·8″ × 10·1″ × 46 lb., safe load 82 tons.

Here we have a saving in weight of 14% and 16% respectively ; and in the first example a 24% increase in strength.

* With this unimportant difference that, whereas in B.S.S. 449 (1937) the stresses are worked out to two places of decimals, the L.C.C. stresses are taken to one place only, as in B.S.S 449 (1934). For general convenience, we have adopted the same course, interpolating to two or more places of decimals for intermediate values of l/g.

SAFE STRESSES IN STANCHIONS.

FOR VARIOUS CONDITIONS OF END FIXING.

Tons per square inch.

l/g	Fidler's Formula.	B.S.S. Mild Steel.	B.S.S. High Tensile.	l/g	Fidler's Formula.	B.S.S. Mild Steel.	B.S.S. High Tensile.	l/g	Fidler's Formula.	B.S.S. Mild Steel.	B.S.S. High Tensile.
	Fixed.	Hinged.	Hinged.		Fixed.	Hinged.	Hinged.		Fixed.	Hinged.	Hinged.
4	5·99	...	...	**70**	5·17	5·41	7·41	**136**	3·26	2·39	2·55
6	5·99	...	...	**72**	5·12	5·31	7·20	**138**	3·20	2·33	2·49
8	5·99	...	...	**74**	5·07	5·20	6·99	**140**	3·14	2·28	2·42
10	5·98	...	...	**76**	5·02	5·09	6·78	**142**	3·09	2·22	2·36
12	5·97	...	...	**78**	4·97	4·99	6·57	**144**	3·04	2·17	2·30
14	5·96	...	...	**80**	4·92	4·88	6·35	**146**	2·99	2·12	2·24
16	5·95	...	...	**82**	4·86	4·77	6·14	**148**	2·93	2·07	2·19
18	5·94	...	...	**84**	4·81	4·66	5·93	**150**	2·88	2·02	2·13
20	5·94	7·17	10·50	**86**	4·75	4·55	5·72	**152**	2·83	1·98	2·08
22	5·92	7·13	10·42	**88**	4·69	4·44	5·52	**154**	2·78	1·93	2·03
24	5·90	7·08	10·35	**90**	4·64	4·33	5·32	**156**	2·74	1·89	1·98
26	5·89	7·03	10·27	**92**	4·58	4·22	5·14	**158**	2·69	1·85	1·94
28	5·87	6·98	10·20	**94**	4·52	4·12	4·95	**160**	2·64	1·81	1·89
30	5·85	6·92	10·11	**96**	4·46	4·01	4·78	**162**	2·60	1·77	1·85
32	5·83	6·87	10·03	**98**	4·40	3·91	4·61	**164**	2·55	1·73	1·81
34	5·81	6·81	9·94	**100**	4·34	3·81	4·45	**166**	2·51	1·69	1·77
36	5·78	6·76	9·85	**102**	4·28	3·71	4·30	**168**	2·46	1·66	1·73
38	5·76	6·70	9·76	**104**	4·22	3·61	4·15	**170**	2·42	1·62	1·69
40	5·74	6·64	9·66	**106**	4·16	3·52	4·02	**172**	2·38	1·59	1·65
42	5·71	6·57	9·55	**108**	4·09	3·43	3·88	**174**	2·34	1·56	1·62
44	5·68	6·51	9·44	**110**	4·03	3·34	3·76	**176**	2·30	1·52	1·58
46	5·64	6·44	9·33	**112**	3·97	3·25	3·64	**178**	2·26	1·49	1·55
48	5·61	6·37	9·21	**114**	3·91	3·17	3·52	**180**	2·22	1·46	1·52
50	5·58	6·30	9·08	**116**	3·85	3·09	3·42	**182**	2·18	1·43	1·49
52	5·55	6·22	8·95	**118**	3·79	3·01	3·31	**184**	2·15	1·41	1·46
54	5·51	6·14	8·81	**120**	3·72	2·93	3·21	**186**	2·11	1·38	1·43
56	5·47	6·06	8·66	**122**	3·66	2·85	3·12	**188**	2·07	1·35	1·40
58	5·43	5·98	8·50	**124**	3·61	2·78	3·03	**190**	2·04	1·33	1·37
60	5·40	5·89	8·34	**126**	3·55	2·71	2·94	**192**	2·01	1·30	1·34
62	5·35	5·80	8·17	**128**	3·49	2·64	2·85	**194**	1·97	1·28	1·32
64	5·31	5·71	7·99	**130**	3·43	2·58	2·78	**196**	1·94	1·25	1·29
66	5·26	5·61	7·80	**132**	3·37	2·51	2·70	**198**	1·91	1·23	1·27
68	5·22	5·51	7·61	**134**	3·31	2·45	2·63	**200**	1·88	1·21	1·24

1. **FIDLER'S FORMULA.** The tabulated stresses are one-fourth of the calculated destructive stresses, assuming a crushing strength of 24 and an elastic modulus of 13,000 tons per square inch. For further details, see Professor T. C. Fidler's paper in *Proceedings of the Institution of Civil Engineers*, Vol. 86.

2. **BRITISH STANDARD.** The stresses tabulated for Hinged ends are those obtained by the B.S.S. 449 (1937) formula for columns having " both ends held in position but unrestrained in direction."

The increased stresses for " High Tensile Steel " are appropriate for steel to B.S.S. 548 (37-43 tons tensile).

NOTES ON STANCHIONS.—Continued.

If similar comparisons be made for stanchions of greater length, the economy of the Broad Flange Beam is still more conspicuous. Thus, for a load of **44** tons and a height of **16** feet, the difference between R.S.J. 9″ × 7″ × 50 lb. (safe load **45** tons) and B.F.B. **8·3″** × **8·5″** × **34½** lb. (safe load **44** tons) is a saving in weight of 31%.

When comparison is made with built-up stanchions, composed of steel joists or channels with plates riveted (or welded) to the flanges, the main economy of the Broad Flange Beam is in the elimination of expensive labours, as illustrated in the case cited on page 8 (Fig. 2), where the use of the plain B.F. Beam shows a saving of 7½% in weight; the elimination of 122 rivets, and a still greater number of drilled holes; and only one piece, instead of four (at least), to be straightened and cut to exact lengths.

In addition to the economy they effect, B.F. Beams offer other general advantages, such as the facilities for connections afforded by their wide flanges and diminished liability to corrosion as compared with riveted stanchions. Moreover, stanchions of plain rolled steel sections can, of course, be produced much more rapidly than riveted stanchions, sometimes a very important consideration.

Subject to the minimum quantities specified on page **286**, the lower tiers of columns in a building can be in the same section as the upper tiers, but rolled to maximum or intermediate weights (see page **11**).

4. ECCENTRIC LOADS.

The tabulated safe loads and stresses are for stanchions centrally loaded. If the loading be one-sided as in Fig. 1, or unbalanced as in Fig. 2, a bending moment is set up in the

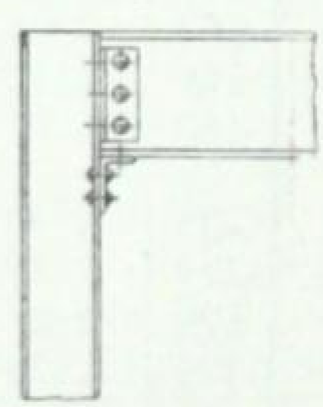


Fig. 1.

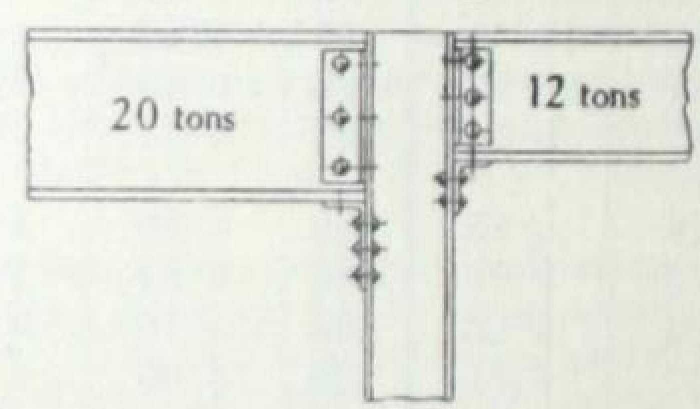


Fig. 2.

stanchion, which increases the compressive stress on the near side of the stanchion, while reducing it on the opposite side.

The principle adopted is to limit the maximum compressive stress in the stanchion to that which would be allowed—over the whole area of the stanchion—if centrally loaded.

The multipliers for eccentric loading given in the tables of safe loads enable this principle to be applied in a very simple manner, as explained below.

In the London County Council By-Laws (and B.S.S. 449) eccentricity of loading is provided for in similar fashion, but the maximum compressive stress is allowed to exceed that permissible for a central load (see page **283** § **17**).

5. ECCENTRIC LOAD MULTIPLIERS.

In the Tables of Safe Loads, "Eccentric Load Multipliers" are given for flange and web connections respectively.

In cases where the eccentric load is transmitted by a girder cleated to the stanchion, as in Figs. 3 and 4, all that is required is to multiply the load by the appropriate multiplier in order to ascertain the equivalent *central* load.

Thus, if Fig. 3 represents a stanchion with fixed ends of 12″ × 12″ section, 19 feet high, and the load transmitted by the girder is 50 tons, the equivalent central load will be $50 \times 2{\cdot}35 = 117\frac{1}{2}$ tons (2·35 being the eccentric load multiplier for a flange connection, as tabulated on page 86).

The Table of Safe Loads (page 87) shews that the safe central load is 122 tons, and, therefore, that the 12″ × 12″ section is suitable.

NOTES ON STANCHIONS.—Continued.

6. BENDING MOMENT MULTIPLIERS.

The " Eccentric Load Multipliers " are only applicable to the case of eccentric loads transmitted by girders cleated to stanchions, as in Figs. 3 and 4. They assume that the point of application of the load is at the face of the stanchion as shewn.

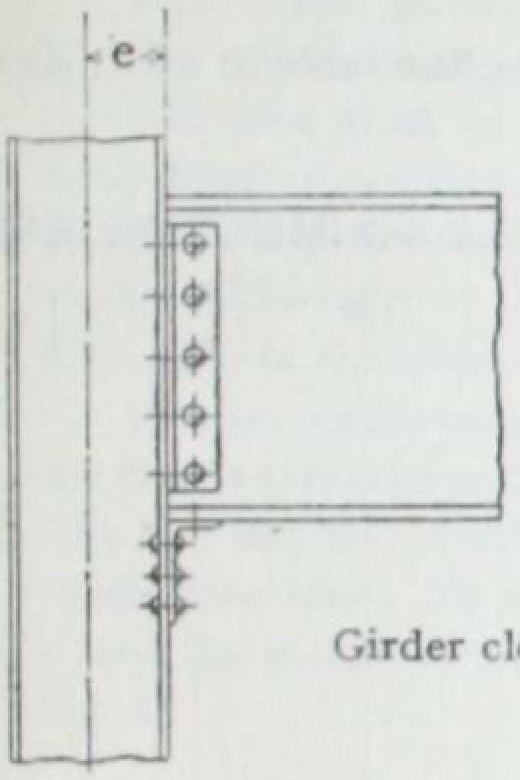


Fig. 3.
Girder cleated to flange.

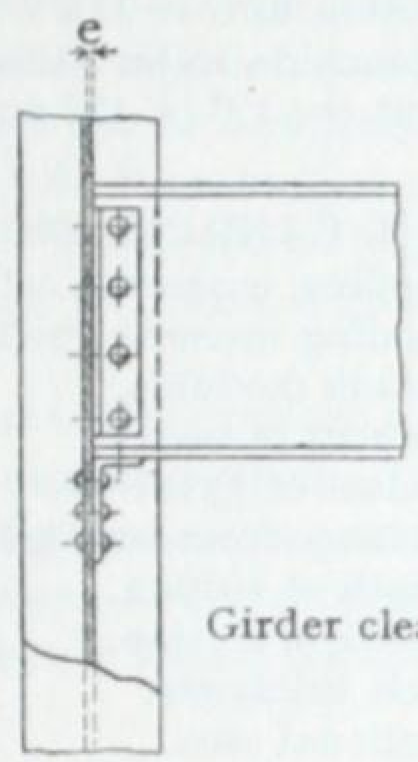


Fig. 4.
Girder cleated to web.

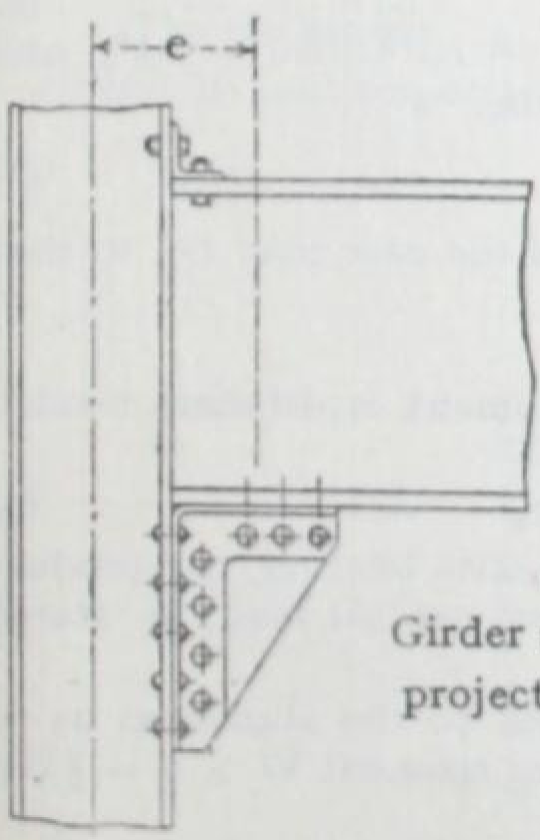


Fig. 5.
Girder supported on projecting bracket.

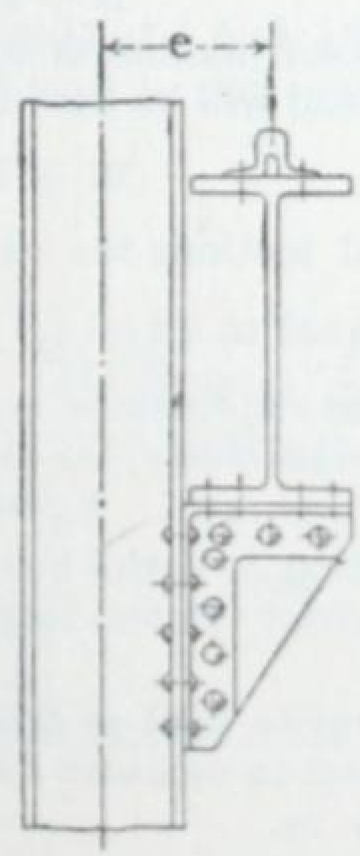


Fig. 6.
Crane Runway supported on projecting bracket.

This assumption is inadmissible if the girder is merely supported on a projecting bracket as in Fig. 5 or in Fig. 6.

In such cases, and where bending moment is induced by wind pressure or other horizontal thrust, the procedure is to calculate the bending moment and multiply this by one of the tabulated " bending moment multipliers," in order to arrive at the equivalent central load.

The procedure is equally simple. In Figs. 5 or 6, if the eccentric load (W) is 30 tons and the distance of the point of application e is 12 inches, then the bending moment is $W \times e = 30 \times 12 = 360$ inch-tons.

NOTES ON STANCHIONS.—Continued.

If the section under consideration is 12″ × 12″, of which the tabulated bending moment multiplier (XX) is 0·23, the equivalent central load is 360 × 0·23 = 82·8 tons.

This only represents the *additional* equivalent central load due to the bending moment; we must therefore add the actual load in order to arrive at the *total* equivalent central load, which will accordingly be 30 + 82·8 = 112·8 tons.

Assuming the stanchion to be 20 feet long and fixed at both ends, the table of safe loads on page 87 shews that the 12″ × 12″ section is correct.

7. FORMULÆ FOR BENDING MOMENT AND ECCENTRIC LOAD MULTIPLIERS.

(i) Let B = Bending moment.
F = Bending moment multiplier as tabulated.
M = Section modulus.
I = Moment of inertia.
g = Radius of gyration.
n = Distance from stressed edge to neutral axis.
d = Depth of section.
b = Width of section.
t = Web thickness.
A = Sectional area.
W = Actual vertical load.

Then the compressive stress due to the vertical load will be

$$W \div A \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (1)$$

The additional compressive stress due to the bending moment will be

$$B \div M = Bn \div I = Bn \div Ag^2 \quad \ldots \quad \ldots \qquad (2)$$

Consequently the total maximum compressive stress will be $(W \div A) + (Bn \div Ag^2)$, and the equivalent central load will be this expression multiplied by A, viz.,

$$W + B\frac{n}{g^2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (3)$$

For all symmetrical sections the value of n will be $\frac{1}{2}d$ or $\frac{1}{2}b$ as the case may be, so that the expression $\frac{n}{g^2}$ is equal to $\frac{1}{2}d \div g_x^2$ and $\frac{1}{2}b \div g_y^2$ respectively.

The values of these expressions are the tabulated bending moment multipliers headed "XX" and "YY" respectively, so that

$$F_x = \tfrac{1}{2}d \div g_x^2 \text{ and } F_y = \tfrac{1}{2}b \div g_y^2 \quad \ldots \quad \ldots \qquad (4)$$

As shewn by equation 3, if the bending moment is due to eccentric loading, the product B × F added to the actual vertical load W gives the *total* equivalent central load, as stated in § 6.

(ii) When the eccentric load is transmitted by a girder cleated to the stanchion as in Fig. 3 or Fig. 4, it is usual to measure *e* as shewn, so that the bending moment $W \times e = \frac{1}{2}Wd$ or $\frac{1}{2}Wt$ as the case may be.

Consequently, the equivalent central load for a flange connection will be

$$W + (\tfrac{1}{2}Wd \times F_x) = W\left(1 + \frac{d^2}{4g_x^2}\right)$$

and for a web connection will be

$$W + (\tfrac{1}{2}Wt \times F_y) = W\left(1 + \frac{bt}{4g_y^2}\right)$$

These coefficients of W are the tabulated "Eccentric Load Multipliers."

Notice that in using the Bending Moment Multipliers, the product of Load and Multiplier gives the equivalent of the bending moment only; whereas the product of Load and Eccentric Load Multiplier gives the *total* equivalent central load.

N.B.—The practice of taking e as only $\frac{1}{2}$d or $\frac{1}{2}$t tends to underestimate the bending moment. On the other hand, any error thus involved may be regarded as counterbalanced by the consideration that, in ordinary building construction, the ends of the stanchions are substantially fixed in position so that the bending moment will decrease from a maximum at the cap to zero at a point of contraflexure in the stanchion. Hence the corresponding bending stress at the mid-height of the stanchion, where the liability to failure is greatest, will not be more than 50% of the maximum.

A more exact procedure would be to take account of the precise mode of connection and the relative lengths and moments of inertia of the connected members. If the girder is relatively long and shallow, it will obviously increase the bending moment, especially if rigidly connected to the stanchion. In such cases, it would be desirable to assign a higher value to e. In cases where the girder simply rests on a projecting bracket, e should certainly be measured as in Fig. 5.

8. COMBINATION OF CENTRAL AND ECCENTRIC LOADS.

Fig. 7 illustrates a stanchion carrying a central load of 40 tons from an upper stanchion and unequal loads from girders on all four sides.

The tie beams " A " are supposed to transmit loads of 4 and 7 tons, and the main girders 25 and 30 tons respectively, so that the total actual load is 106 tons.

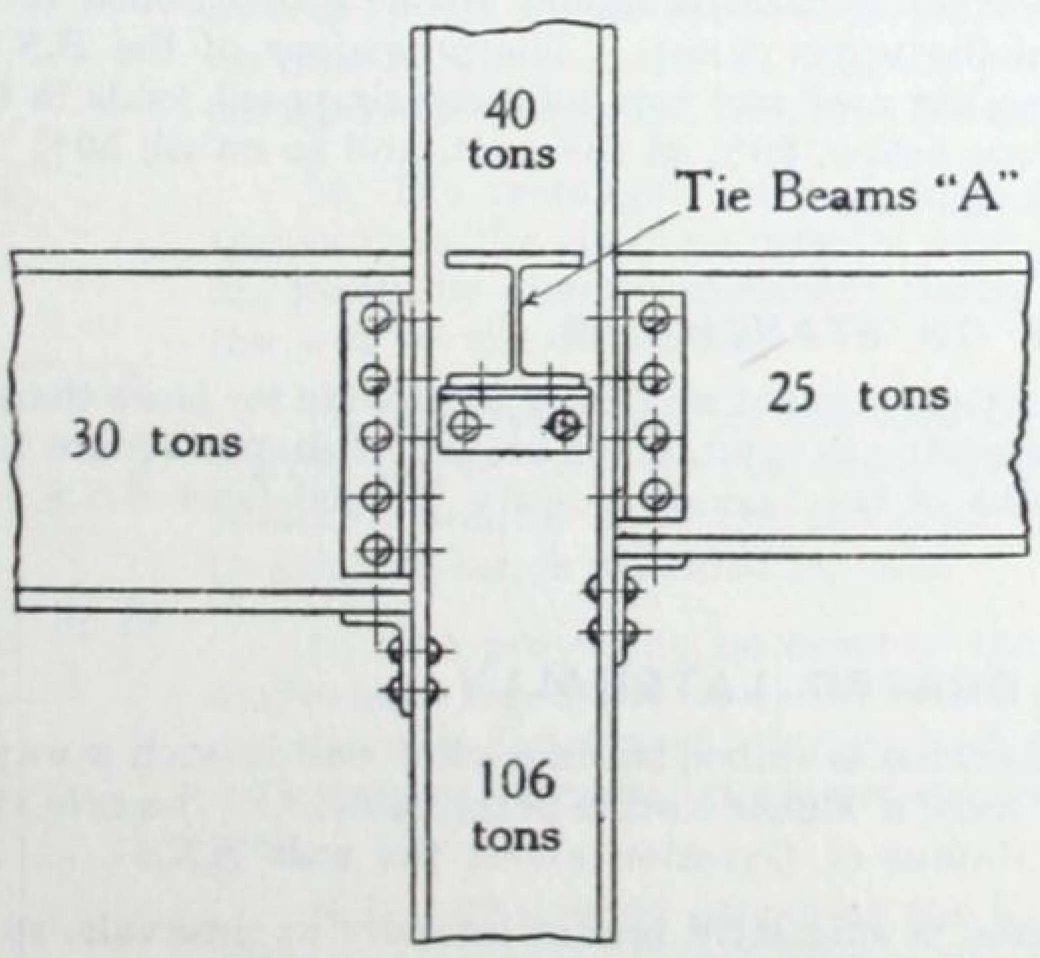


Fig. 7.

NOTES ON STANCHIONS.—Continued.

Assuming the stanchion to be 12″ × 12″, the calculation is as follows :—

	Actual Load.	Multiplier.	Equivalent Central Load.
	Tons.		Tons.
From stanchion above	40	...	40·0
Balanced loads on flanges	50	...	50·0
Unbalanced load on flange	5	2·35	11·8
Balanced loads on web	8	...	8·0
Unbalanced load on web	3	1·15	3·5
Total	106	...	113·3

9. TRANSMISSION OF LOADS TO LOWER STANCHIONS.

(*a*) The bending stresses set up at the junction of girder and stanchion affect the stresses in the stanchion from top to bottom, but those due to loads on one floor tend to neutralise those due to the loads on the floors above and below. It is, therefore, quite good practice in selecting a suitable section for a stanchion, to ignore the eccentricity of the loads on the stanchions above it. It follows that, when converting bending moments and eccentric loads into equivalent central loads, the latter should be set out separately in the calculations, as it is only the actual load on the stanchion above which need be provided for in the stanchion below.

(*b*) Unless there is a reasonable probability of all floors being fully loaded simultaneously, as in a warehouse, the lower stanchions should not be proportioned to carry the whole of the calculated live loads of the upper floors. The provisions of the B.S.S. 449, § 8b, represent good practice, viz., take the roof and top floor superimposed loads in full. Take 90% of the live load of the next floor below, 80% of the next, and so on till 50% is reached, after which no further reduction is allowed.

10. WIND LOADS ON STANCHIONS.

In building construction, it is not necessary to provide for more than 75% of the calculated loads (real and equivalent) due to wind, taken at, say 30 lb. per square foot of exposed vertical surface. The provisions of the London County Council (and B.S.S. 449) will be found on page 283 § 18.

11. STANCHIONS BRACED LATERALLY.

(*a*) When an **H** stanchion is embedded in a solid wall in such a way as to prevent it from bending about the YY axis, a higher load is permissible, *i.e.*, the safe stress can be calculated with reference to the Radius of Gyration about the axis XX.

(*b*) When a stanchion is efficiently braced laterally at intervals, so as to prevent it from bending as a whole, it may be treated as a series of independent superimposed stanchions, as in the case of an ordinary steel-frame building of two or more storeys.

In the case of an exposed structure, such bracing is rarely sufficiently substantial to justify a greater stress than that allowed for a strut with hinged ends.

(*c*) If a stanchion is thus braced in its weaker direction only, there may be a greater liability for the stanchion to bend as a whole about its XX axis than for any of its separate portions to bend about its YY axis.

12. LATTICED MEMBERS.

For many purposes, highly efficient compression members are obtained by latticed sections consisting of a pair of channels or beams, or of four angles, etc. The lattice bars are usually flats or angles at 60° with the axis if single, or 45° with the axis if crossed. Their thickness is usually about 1/40th of the length for single lacing and 1/60th for double lacing.

The foregoing and other details will be found in § 26 of B.S.S. 449.

A system of latticing which itself is capable of acting as a strut, independent of the members it connects (*e.g.*, double latticing with horizontal members across the diagonals), should be avoided, as it may fail under stresses for which it is not intended, and thereby lead to the failure of the column as a whole.

13. STANCHION BASES ON REINFORCED CONCRETE FOUNDATIONS.

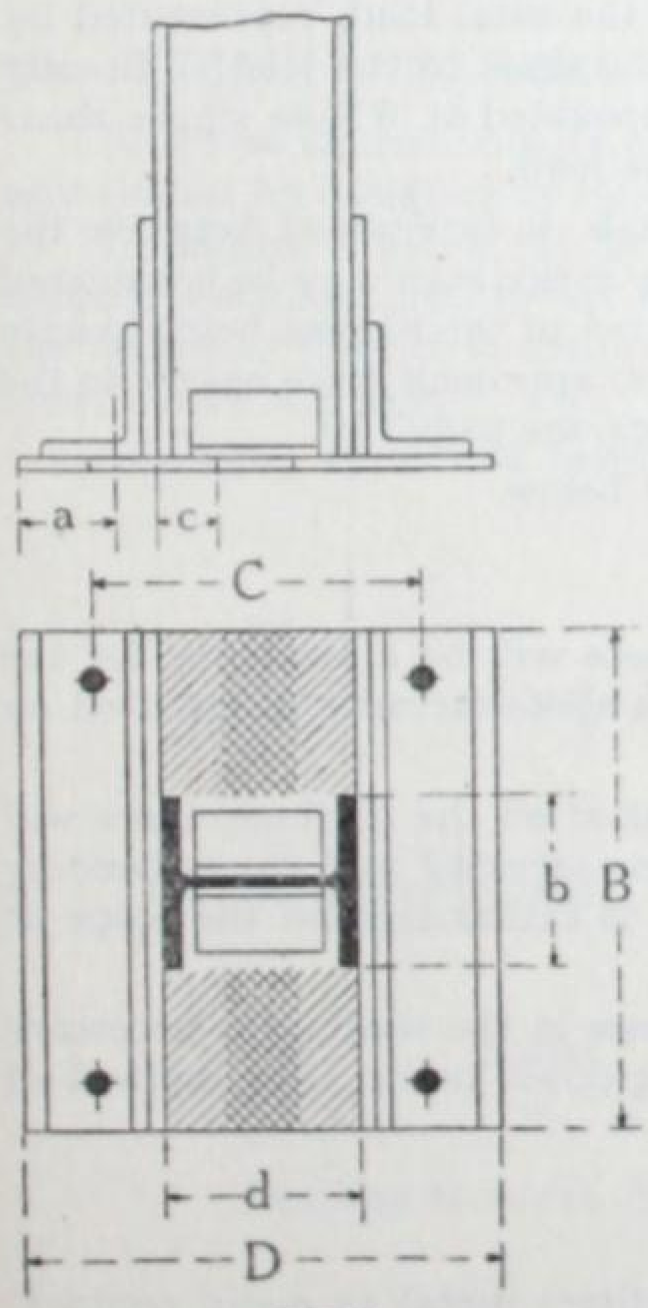


Fig. 8.

The commonest form of base is that shewn diagrammatically in Fig. 8. Gusset plates are riveted to the flanges of the shaft and the base plate is attached by means of angles. Rivets are not shewn in the sketch, but holes for the holding down bolts referred to in § 15 are indicated. For stanchions on reinforced concrete foundations capable of bearing a maximum safe pressure of 500 lb. per square inch (32 tons per square foot approx.) the mode of calculation is as follows :—

(*a*) The rectangular area d × b in Fig. 8 is assumed to transmit to the shaft an upward load equal to d × b × 500 lb., partly by direct contact and partly by the rivets through the web of the stanchion.

(*b*) The remainder of the load is assumed to be transmitted to the shaft by the rivets through its flanges ; and a sufficient number of rivets, taken at 6 tons per square inch in single shear, is provided for this.

(*c*) The projecting portions of the base plate and flange angles (*a* in Fig. 8) are assumed to act as cantilevers carrying a uniformly distributed upward load of such an amount as will produce a flexural stress not exceeding 10 tons per square inch.

N.B.—The rivets attaching the flange angles to the base plate are assumed to act merely as connections, and not as making the angle legs and the base plate act as one solid plate.

(*d*) The portions of the base plate shown lightly hatched in Fig. 8 are assumed to transmit such a pressure as will produce a flexural stress equal to that in the projecting portions of the base, thereby balancing the same.

(*e*) The areas beneath the edges of gusset plates and under the vertical legs and fillets of the flange angles, are assumed to transmit an upward load of 500 lb. per square inch through the rivets to the flanges.

Accordingly, the pressure on the concrete is taken as 500 lb. per square inch over the areas enumerated in paragraphs (*a*) and (*e*) above; the double-hatched area in Fig. 8 is treated as ineffective; the pressure under the remaining portions of the base—being limited, as explained above, by the allowable flexural stress in the steel—will be *less* than 500 lb. per square inch.

It is sometimes assumed, for purposes of calculation, that the pressure on the concrete is distributed uniformly over the whole area of the base plate. This is obviously incorrect, inasmuch as the deflection of the projecting portions of the plate and angles will relieve the pressure beneath them in the manner assumed above.

If the load on the stanchion is less than assumed, or the foundations better than reinforced concrete, the area of the base plate can, of course, be reduced, taking care, however, that the projecting portions of the steel base are not over-stressed. For standard riveted and welded bases, see pages 112 to 149.

14. STANCHION BASES ON GRILLAGE FOUNDATIONS.

In the case of bases for grillage foundations, the mode of calculation is similar to that explained in the previous paragraph. That is, a proportion of the total load, represented by the area b × d in Fig. 8, is considered as passing direct from the shaft to the joist(s) directly below it; a sufficient number of rivets through the flanges is provided at 6 tons single shear (or twice this for double shear), to transmit the remainder of the load.

Where a suitable cast-iron webbed base, or plain steel slab, is interposed between the stanchion and grillage joists, as preferred by some engineers, the entire load may be considered as transmitted by direct contact, the function of the angles riveted to the flanges being partly to enable the shaft to be bolted to the base and partly in order to approach more nearly to the condition of " fixed " ends. For further particulars of slab bases, see page 150.

For notes on the design of Grillage Foundations, see § 19 below.

15. OVERTURNING MOMENT IN BASES.

When there is a bending moment in a stanchion shaft there will be a tendency for the base not to remain horizontal, so that the pressure will not be symmetrically distributed on the footings and foundations.

If the shaft is not central on the base, or the base not central on the footings, there will be the same turning tendency, which will increase with the eccentricity and cause bending in the shaft; but a discussion of the treatment in such cases is rather beyond the scope of this book.

If the bending moment in a stanchion induces tensile stresses in the shaft, it is necessary to anchor the base down to the footings by means of holding-down bolts. For method of calculation, see § 22 below.

16. CONNECTIONS OF BEAMS TO STANCHIONS.

The load from a girder is transmitted to a stanchion by direct metal to metal contact, or by means of a bracket riveted or welded to the stanchion. In the former case the connecting

angles need not be considered as taking any portion of the vertical load unless the direct bearing on the stanchion is not sufficient to keep the bearing stresses within safe limits.

17. STANCHION JOINTS.

Joints are usually made in stanchions above the floor level by means of cover plates on flanges and web. The butting ends should be machined to ensure close bearing, as otherwise the whole load has to be transmitted through the plates.

An alternative method is to make the joint immediately below the main girders. In this case, stanchion web cleats and a cover plate should be used to assist in distributing the load over the lower shaft. Details of welded and riveted caps, bases and joints will be found on pages 112 to 149.

18. PRESSURE ON FOUNDATIONS.

The allowable pressure on the soil or rock on which foundations rest may vary from 1 to 15 tons per square foot, or even more, according to the nature of the ground.

Those given as a general guide in B.S.S. 449 will be found on page 285, and accord with average practice.

If the footings are not large enough sufficiently to distribute the pressure, the bearing area may be increased by a steel joist grillage (see below), by a stone slab, or by a concrete base, plain or reinforced.

19. STEEL GRILLAGES.

(i) These consist usually of two or three tiers of joists crossing one another at right angles, and should be designed as follows :—

In figure 9 below, if $2b$ is the width of the wall or stanchion base, the projecting lengths a are assumed to act as cantilevers carrying a uniformly distributed upward load, and the length of joist $2b$ is assumed to be uniformly loaded by the difference between the loads from above and below.

The load, shear and bending moment diagrams are, therefore, as illustrated in Fig. 9.

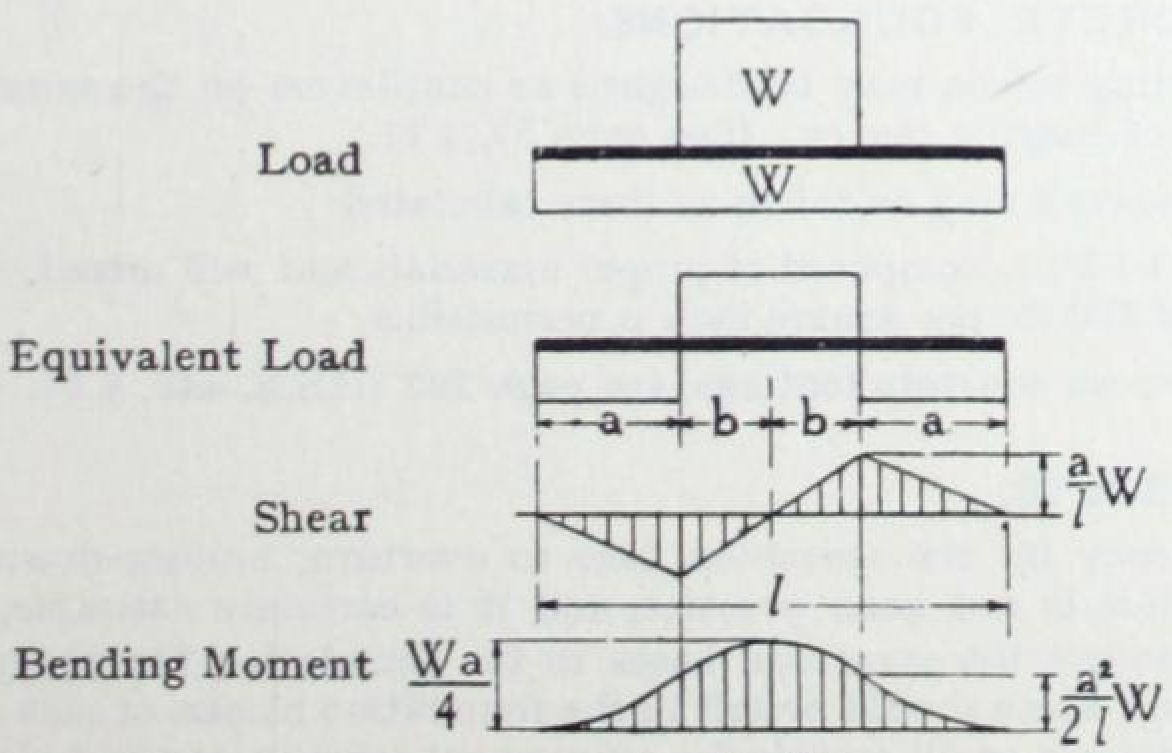


Fig. 9.

The length $2b$ may be taken as the overall width of a cast iron base or as the distance between the outer rows of rivet holes in the case of a riveted steel base. For the lower tiers, $2b$ may be taken as the distance between the centres of the outside joists of the tier above.

(ii) The web of the grillage joist has to act as a column, and the direct stress should not be greater than the safe stress for a strut with fixed ends of which the l/g equals $\sqrt{12} \times$ the nett depth of the web $\div$ web thickness. (These stresses are tabulated for ordinary joists in the column headed P_1 on page **175**, and for Broad Flange Beams on page 38.) The pressure may be taken as distributed over an additional length of web equal to 3/10ths of the depth of the joist on each side of the load. This aspect is dealt with more fully in the notes on Stresses in Girders (see page 62, § 4).

(iii) The London County Council By-Laws (and B.S.S. 449) allow the stresses in grillage beams to exceed the ordinary working stresses by 50%, subject to the beams being adequately embedded in concrete; see page 282.

To prevent corrosion of the joists, they should have a covering of concrete at least 3" thick, and to enable the concrete to be well rammed, a space at least 3" wide should be left between the flanges in each layer.

The top layer of joists should be as close as practicable, to get the requisite web area to resist the shear; the lower layers may be spaced at say 12" to 18" centres.

The joists should be tied together by rods to prevent them spreading during tamping, and spaced by tubular distance pieces, unless separators are required to stiffen the webs.

The projections of the joists should not exceed about 3 to 4 times their depth.

The base of the stanchion should be bolted to the top flanges of the first layer, which in turn should be connected to the layer below, but no deductions need be made for bolt holes if the foregoing method of calculation is employed.

It is advisable to bed the bottom layer of joists on steel bearing plates to facilitate the moving and wedging up of the grillage as a whole when plumbing and levelling the stanchions and first floor beams.

It is well to wedge up the ends of the bottom layer of joists, and not to fill in with concrete till a considerable load is on them, as the deflection induced will help to distribute the load more uniformly on the completed grillage.

20. STONE AND CONCRETE FOUNDATIONS.

Other forms of distributing media may be designed as cantilevers on the same principles as employed for the design of bearing plates. (See page 57, § 11.)

The safe stresses in stonework may be taken as there tabulated.

For reinforced concrete 1 : 2 : 4, composed of proper materials and well mixed, an extreme flexural compressive stress of 600 lb. per square inch is permissible.

For permissible pressures on concrete footings, see page **285** (B.S.S. 449, § F).

21. HOLDING-DOWN BOLTS.

When there is no tendency for the stanchion base to overturn, holding-down bolts are occasionally omitted; but this is not good practice, and it is certainly desirable, especially during erection, always to secure the stanchion bases to the foundation blocks by means of holding-down bolts. Holes for these should be left in the foundation blocks, of such a diameter as to allow the steelwork erector a small margin for adjustment when lining and plumbing the stanchions, after which the voids must, of course, be filled up with liquid cement.

NOTES ON STANCHIONS.—Continued.

22. DIAMETER OF HOLDING-DOWN BOLTS.

If there is bending moment inducing tensile stresses in the shaft at the base, the requisite diameter of the bolts can be ascertained as follows :—

If B = the total bending moment (inch-tons),

C = the distance (inches) centre to centre of the bolts in the direction of overturning,

W = central load on the stanchion (tons),

then $(B \div C) - (W \div 2)$ is the commonly assumed value of the tension (tons) to be taken up by the bolts on the tensile side of the stanchion. This value, however, is too low, as the centre of compression will be nearer the centre of the shaft than the holding-down bolts. For this reason the working stress on the bolts should be reduced to 6 tons per square inch for steel.

23. WIND BRACING.

A good system of heavy bracing, composed of angles riveted to flame-cut pieces of the same section as the main girder, is shown in Fig. 10 : the girder in this example is one of the larger sizes of Broad Flange Beams. A less efficient method, but suitable for medium loads and occupying a minimum of space, is shown in Fig. 11, the tees being cut from R.S. Joists.

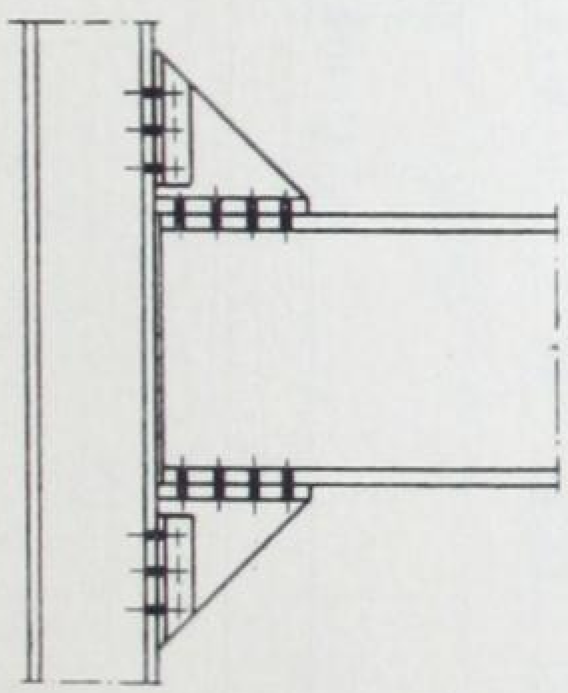


Fig. 10.

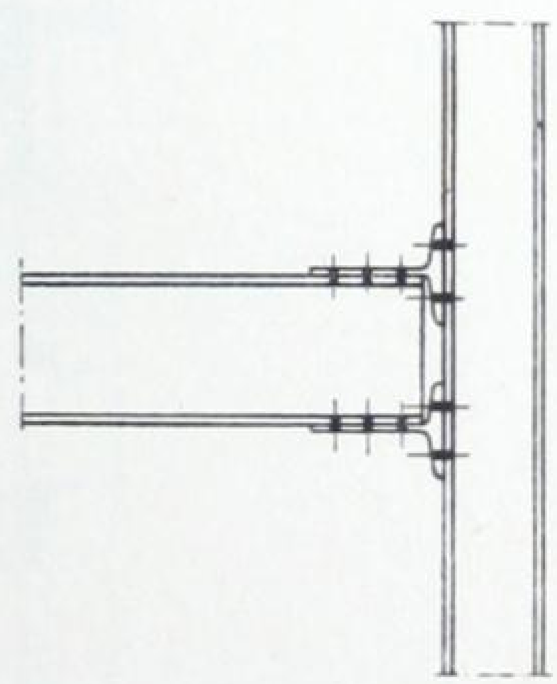
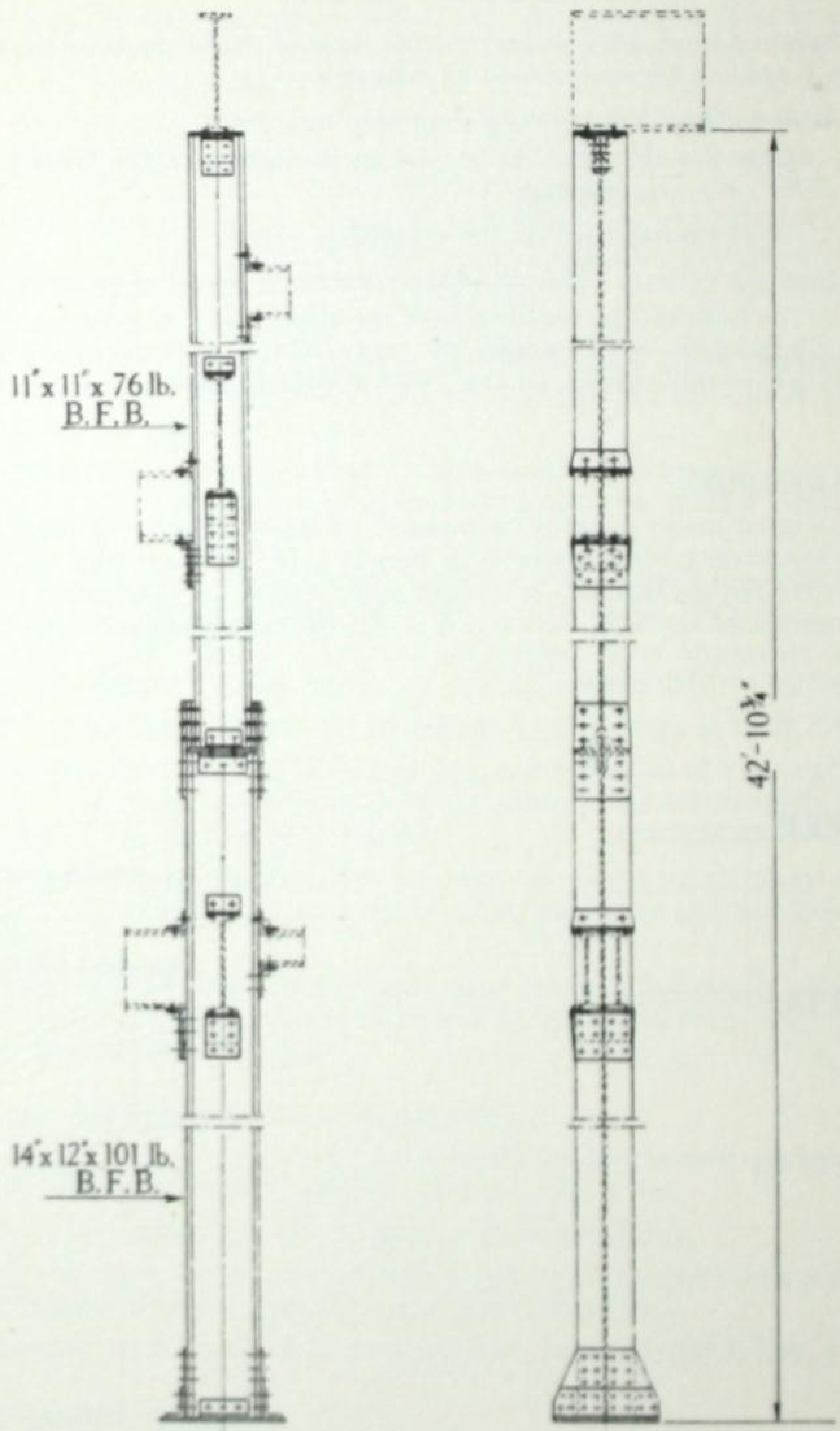


Fig. 11.

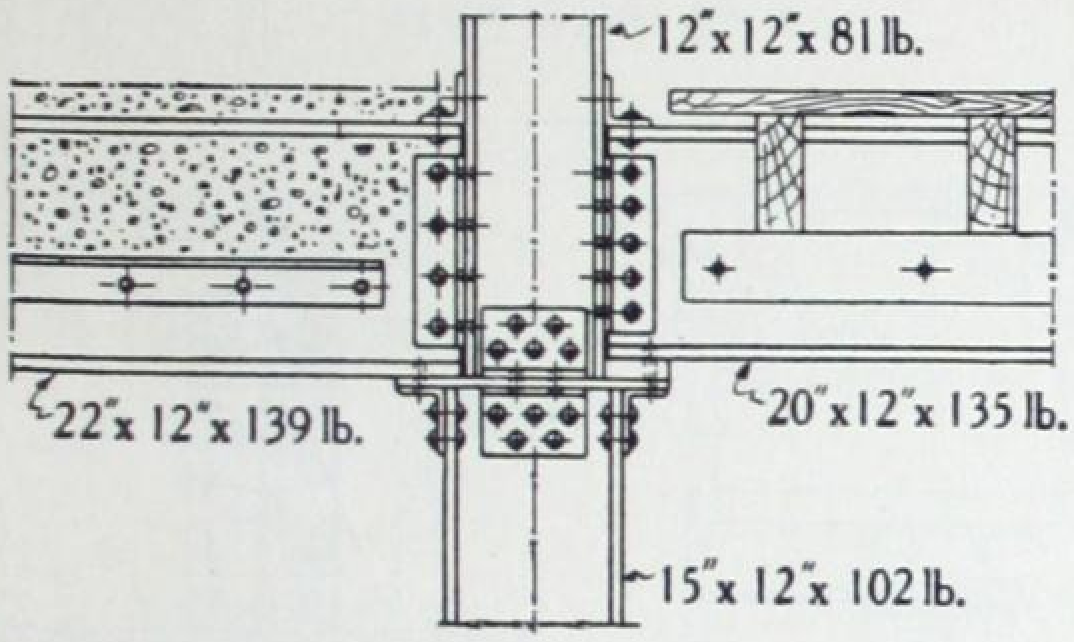
TYPICAL STANCHION DETAILS.

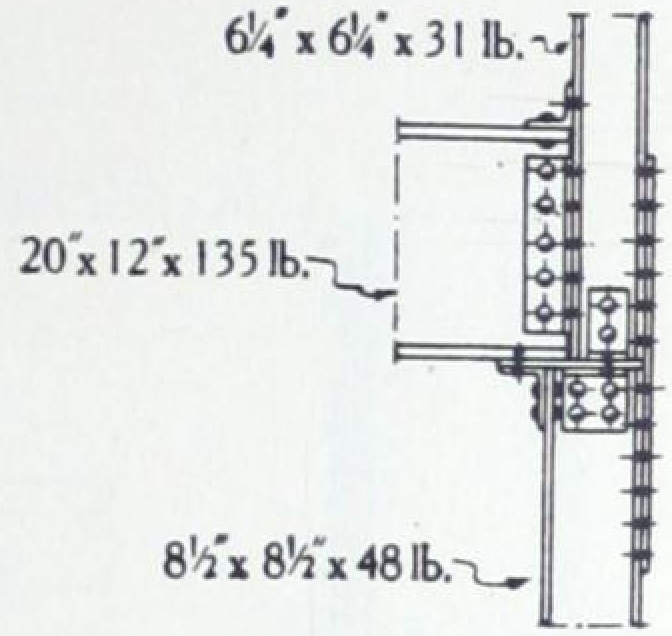
For similar typical welded connections, see pages 243, 244.

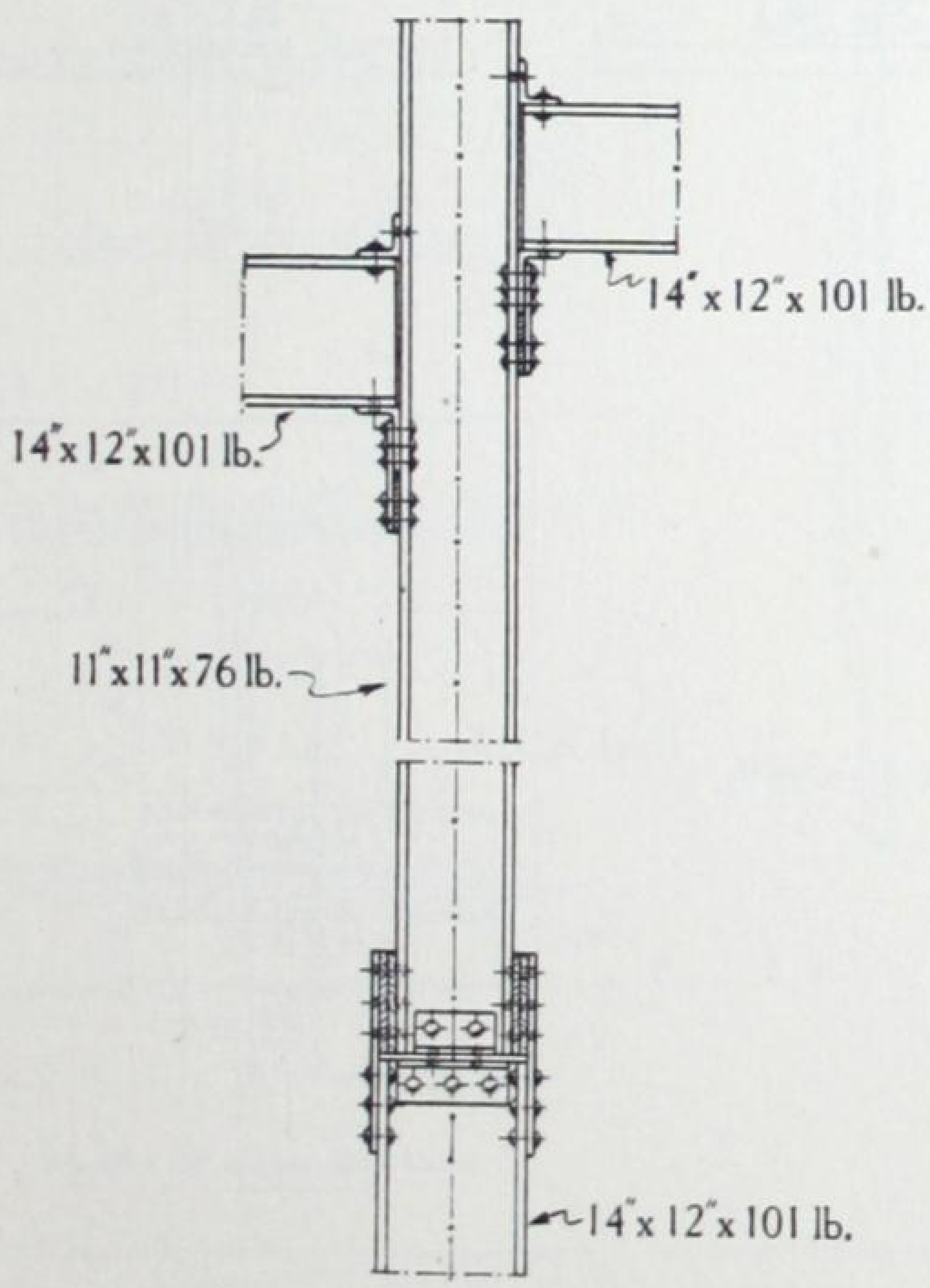


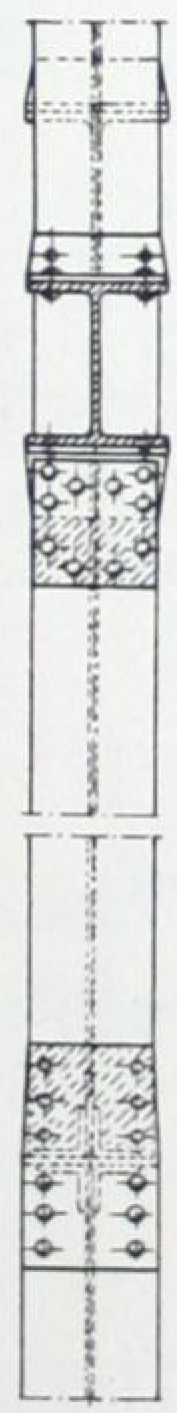
The stanchion stack illustrated above is one of a number in a drapery store at Cork; the sections being 14" × 12" × 101 lb. and 11" × 11" × 76 lb. For further details, see lower drawings on page 107.

TYPICAL STANCHION DETAILS.



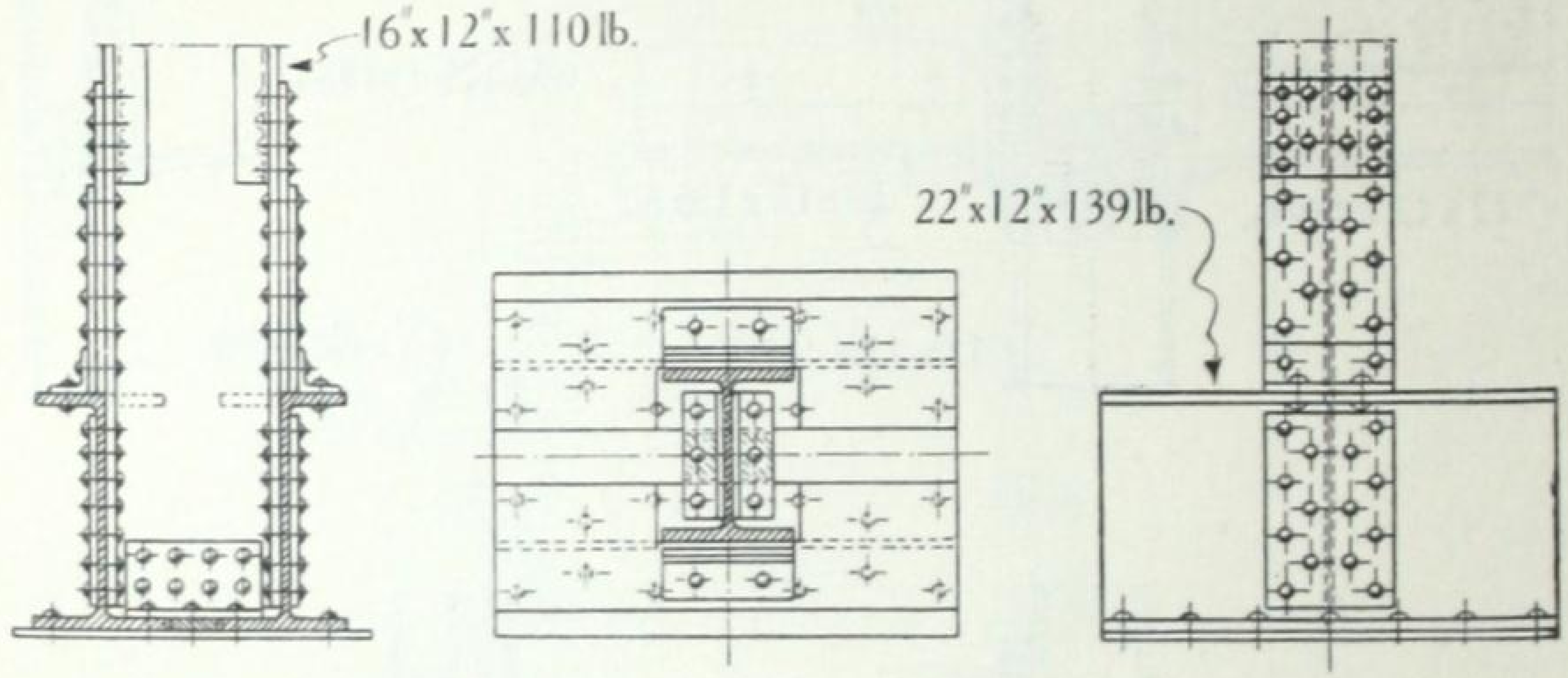


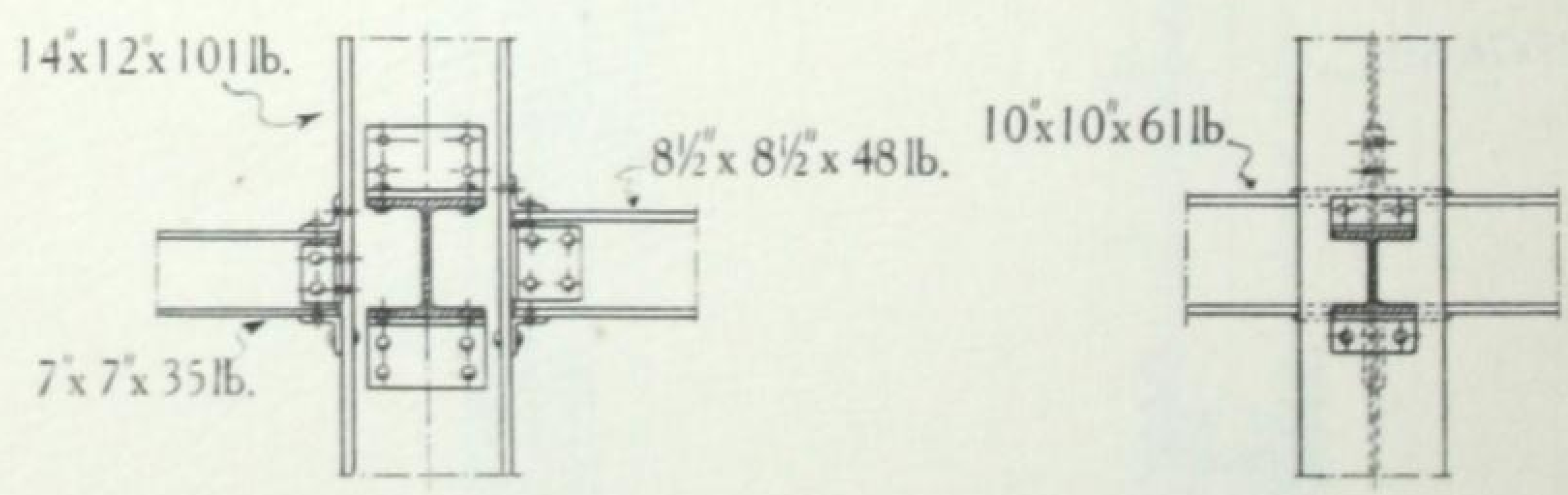




The upper drawings illustrate floor beam connections in a factory extension at Kilmarnock. The lower drawings show stanchions in a drapery store at Cork ; for further details, see page 106 opposite.

TYPICAL STANCHION DETAILS.



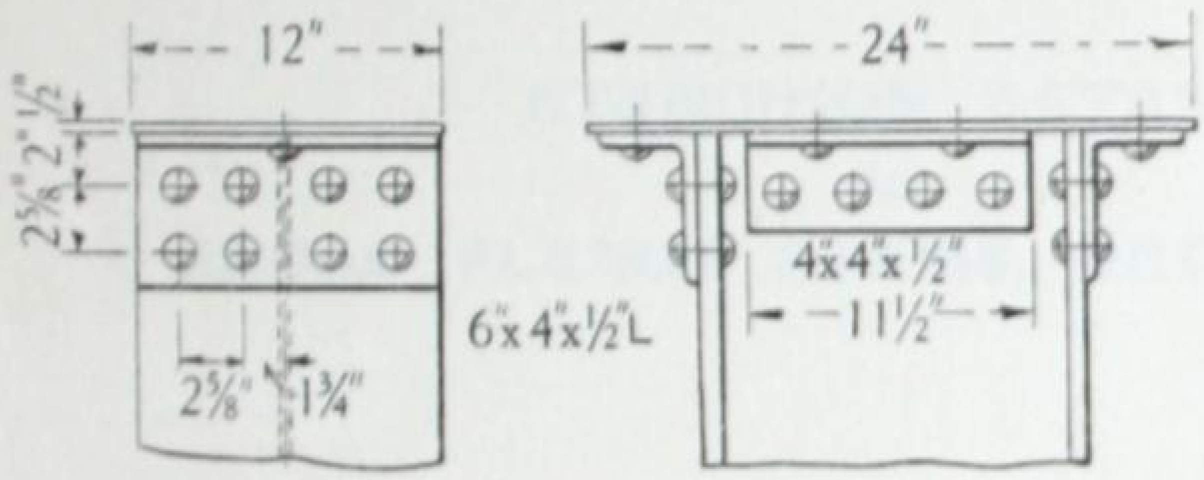


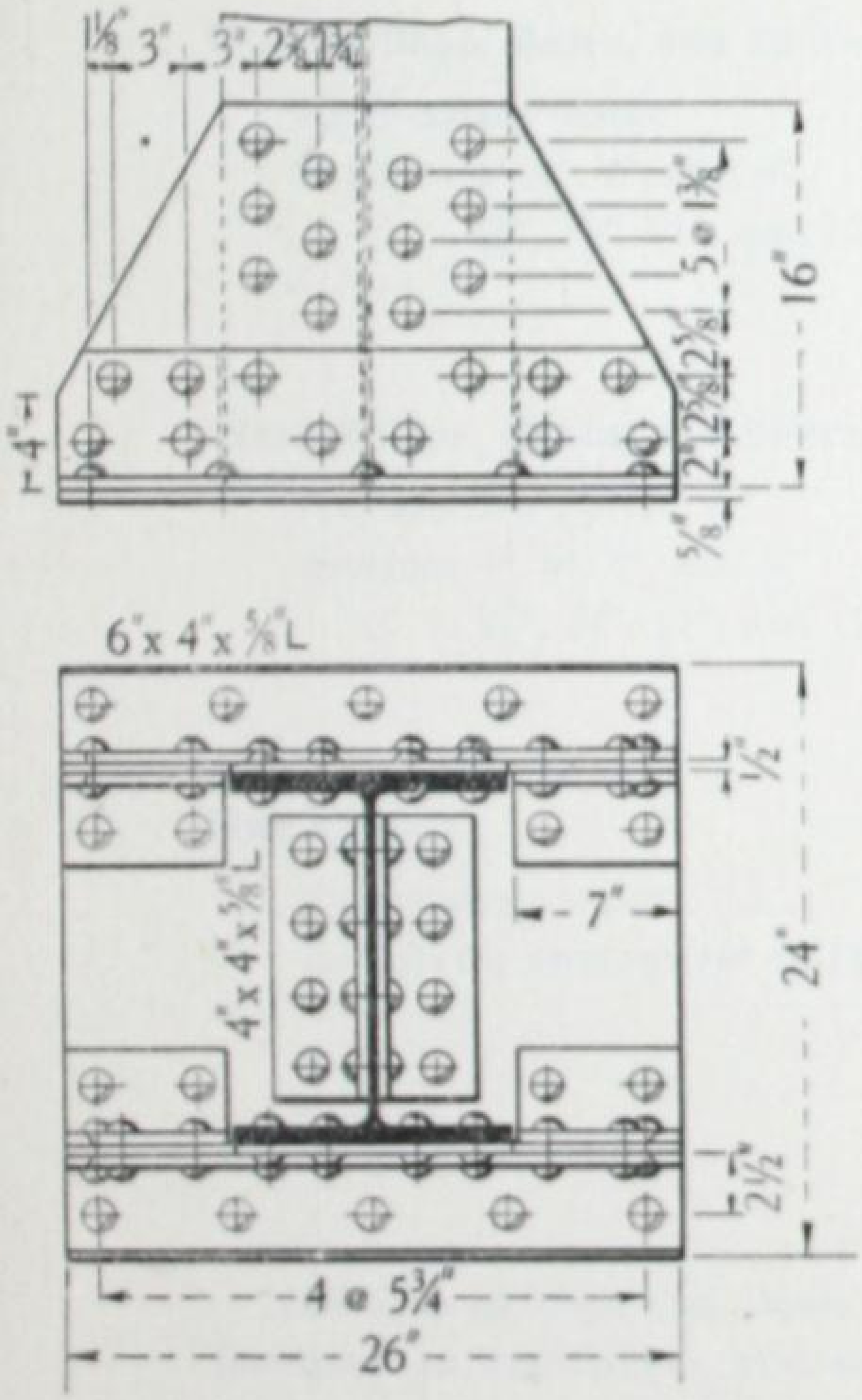
The upper drawings show the foot of a B.F. Beam column, section 16" × 12" × 110 lb., with the load distributed by the use of B.F.B. 22" × 12" × 139 lb.

The lower drawings show a typical four-way connection of girders to a 14" × 12" B.F.B. stanchion.

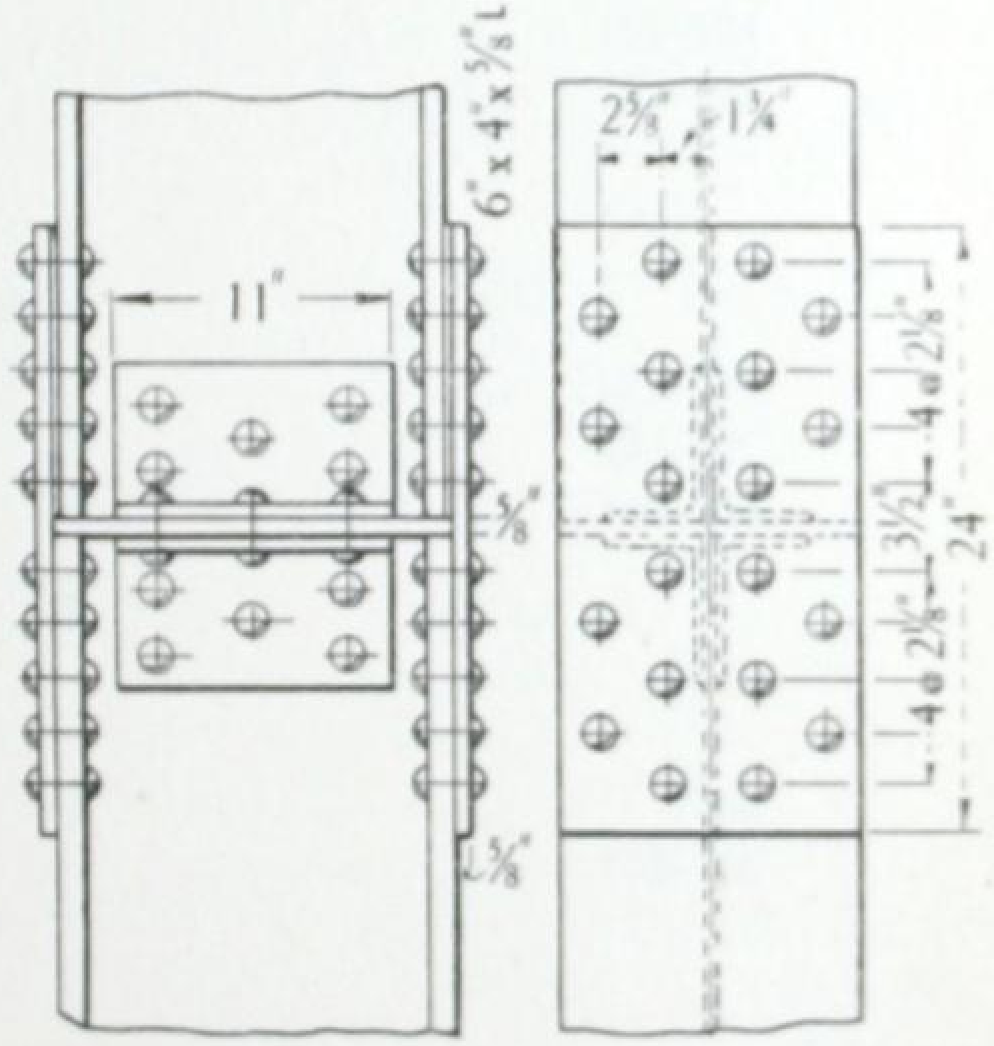
TYPICAL STANCHION DETAILS

Weight of Cap, 106 lb.





Weight of Base, 393 lb.



Weight of joint 259 lb.

Rivets ⅞" dia.

Scale ⅛ inch = 1 foot.

Standard connections for B.F. Beams as stanchions are given in a separate chapter on "Caps and Bases" for sections up to 12" × 12". Above are suitable connections for a column 16" × 12" × 85 lb. (section 16" DIE), assuming a load of 139 tons. On the right, this section is shewn spliced to a 16" × 12" × 110 lb. (section 16" DIN).

For corresponding welded details, see page 246.

STANCHION DETAILS
for
BROAD FLANGE BEAMS, GREY PROCESS.

Designs of Caps and Bases to suit other sections and loads can be furnished on application, at a small or nominal charge for each separate design.

RIVETED CAPS, BASES, AND JOINTS
FOR BROAD FLANGE BEAMS, GREY PROCESS.

For Welded alternatives, see pp. 132–139. For Slab bases, see pp. 150–152.

The following notes relate to the riveted designs of Caps, Bases, and Splice Joints on pages 114 to 129. Details are given for the undermentioned sections in their minimum and medium weights; to avoid confusion, the drawings are marked DIE and DIN respectively.

						Pages
4″ × 4″ × 11·0	and	14·8	lb. per foot	...	...	114, 115
6″ × 6″ × 17·6	,,	24·9	,, ,, ,,	...	...	116, 117
7″ × 7″ × 24·8	,,	34·7	,, ,, ,,	...	...	118, 119
8″ × 8″ × 30·1	,,	43·6	,, ,, ,,	...	...	120, 121
8½″ × 8½″ × 34·5	,,	48·0	,, ,, ,,	...	...	122, 123
10″ × 10″ × 44·2	,,	61·1	,, ,, ,,	...	...	124, 125
11″ × 11″ × 51·4	,,	75·7	,, ,, ,,	...	...	126, 127
12″ × 12″ × 58·9	,,	81·2	,, ,, ,,	...	...	128, 129

WEIGHTS OF CONNECTIONS.

The stated weights allow for rivet heads but not for field rivets or bolts, nor for holding-down bolts.

CAPS.

The stated shear values of the rivets are based on 6 tons per sq. in. single shear; the thicknesses of the angles are sufficient to give a bearing value of not less than 12 tons per sq. in. The choice between the "heavy" and "light" types will depend of course on the size and capacity of the girders to be supported.

With 11″ and 12″ flanges, double rows of bolts and rivets may be used, thereby dispensing with the gusseted brackets usually required with built-up stanchions. See pages 127 to 129.

SLEEVE JOINTS.

These are designed to suit stanchions of the same nominal section, but of the DIE and DIN weights respectively. Sufficient rivets at 6 tons single shear, or twice this amount in double shear, are provided to transmit 60% of the safe loads tabulated on pages 84–91 for the minimum weight and a height of 12 feet.

[When the two stanchions are of *different* sections, such joints must be arranged in the manner shown on page 107.]

BASES.

As indicated in the notes to the various drawings, it may in some cases be necessary to distribute the load over a greater area of the foundation, by means of

For Welded alternatives, see pp. 132–139. For Slab bases, see pp. 150–152.

grillage joists for example. [For notes on the design of grillage foundations, see page 103.]

The "alternative" bases shown (for sections up to 7″ × 7″) are to be preferred for small and urgent orders, being designed to suit stock sizes of angles.

The reinforced concrete foundations are assumed to be capable of bearing a pressure of 500 lb. per sq. in. (32 tons per sq. ft. approx.). The assumed load on the stanchion is the safe central load for a stanchion 12 feet high as tabulated on pages 84–91 (B.S.S. formula, hinged ends, mild steel).

PRINCIPLES OF DESIGN.

The bases conform with the general principles already indicated on page 101 namely :—

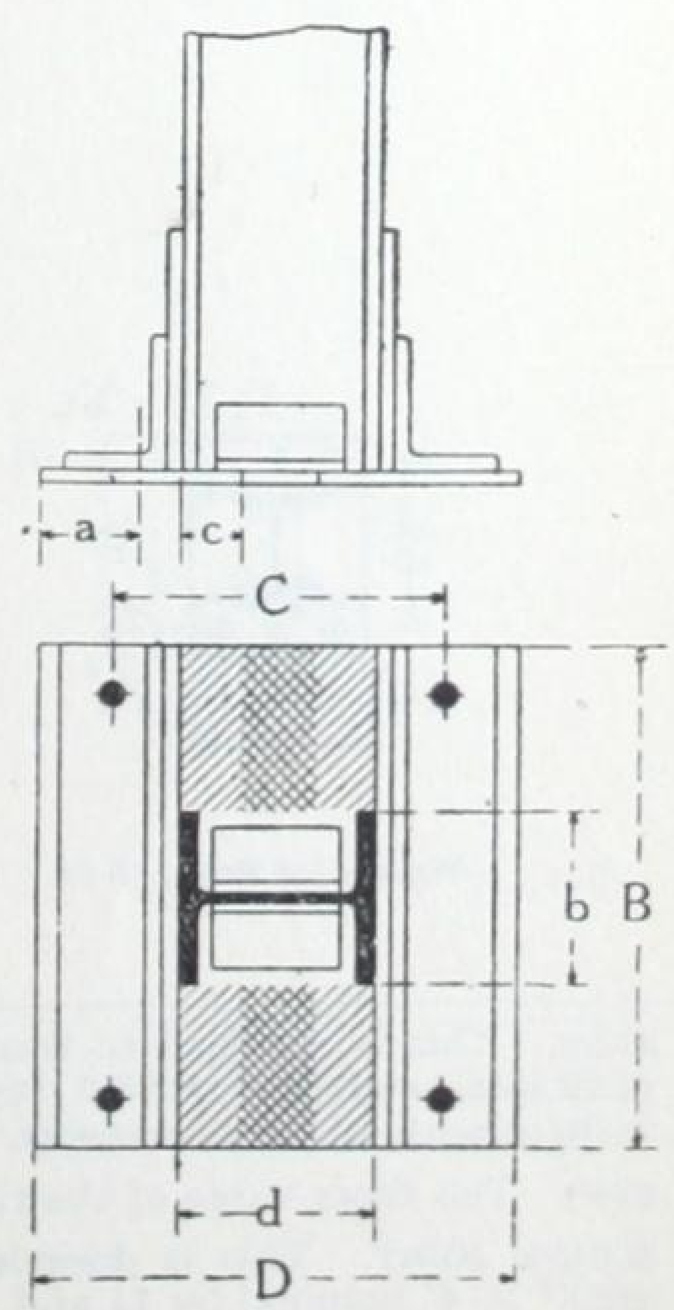
(*a*) The area $d \times b$ in the annexed illustration is assumed to transmit its share of the upward load to the shaft partly by direct contact and partly by the rivets through the web of the stanchion.

(*b*) A sufficient number of rivets through the flanges are provided at 6 tons single shear (or twice this for double shear), to transmit the remainder of the load.

(*c*) The projecting portions 'a' of the base plate and flange angles are assumed to act as cantilevers carrying a uniformly distributed upward load of such an amount as will produce a flexural stress not exceeding 10 tons per sq. in.

(*d*) The portions of the base plate shown lightly hatched are assumed to transmit such a pressure as will produce a flexural stress equal to that in the projecting portions of the base, thereby balancing the same.

(*e*) The double-hatched area is treated as ineffective.



N.B.—For further notes on the design of stanchions, see previous chapter ("Column Notes").

Poles, Piles.
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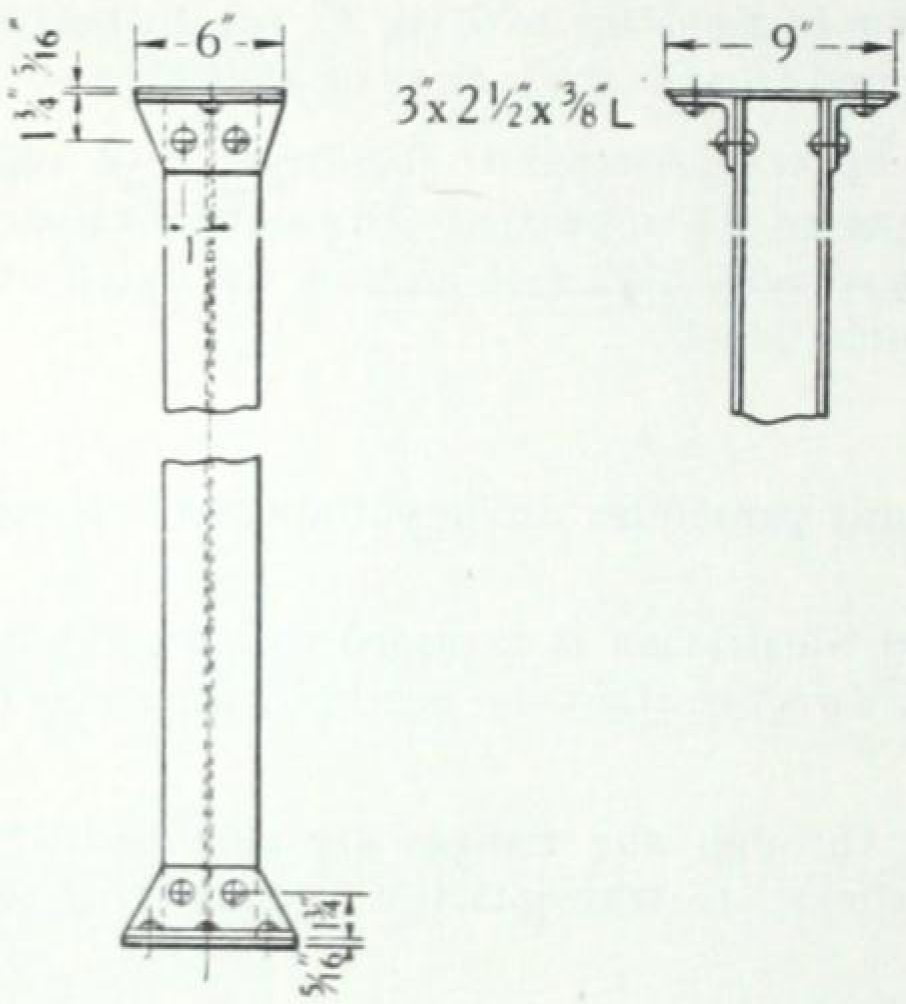
Rivets, Bolts.
Roofs, Concrete
Welding
Plates, Inertia
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

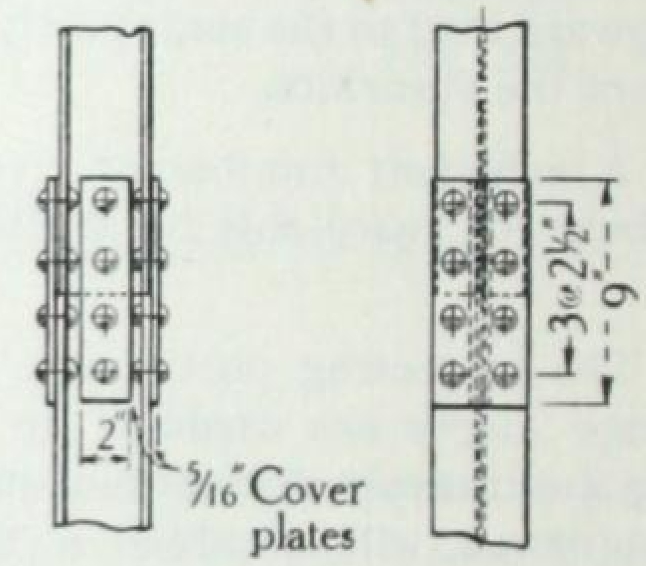
STANDARD STANCHION DETAILS FOR
B.F. BEAM, 4″ × 4″ × 11 lb., GREY PROCESS.

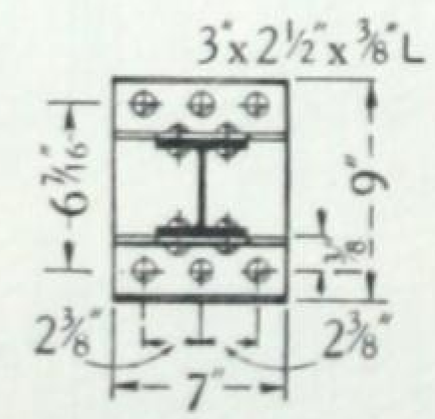
For Welded Alternatives, see page 135.

Weight of Cap, 11 lb.



DIE





Weight of joint 13 lb.

Rivets ⅝″ dia.

Weight of Base, 13 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 6·7 tons, the safe central load for a height of 12 feet, as given on p. 85. Its area, ·44 sq. feet, is sufficient for any good concrete foundation, with or without reinforcement.

CAP. The shear value of the rivets in *each* flange cleat is 3·7 tons.

SLEEVE JOINT. This is designed to transmit a load of 6·7 tons. The sizes shown joined are 4″ × 4″ nominal by 11 and 15 lb. respectively.

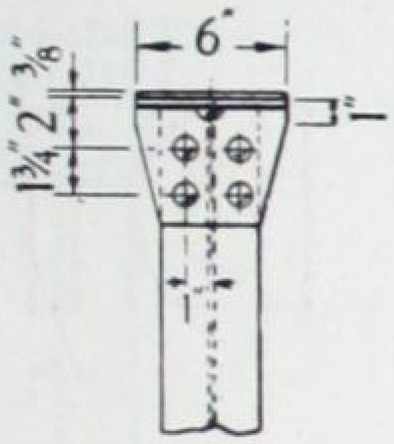
For further explanation, see page 112.

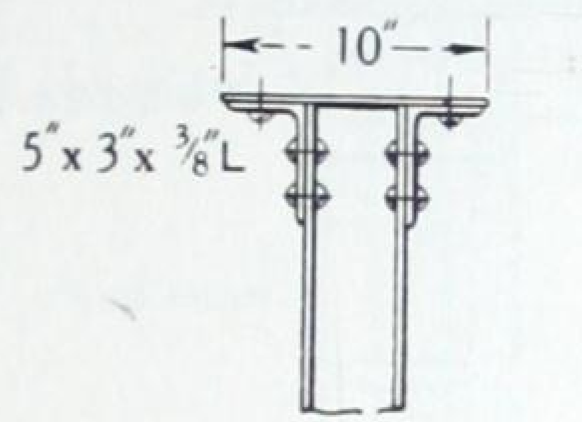
STANDARD STANCHION DETAILS FOR

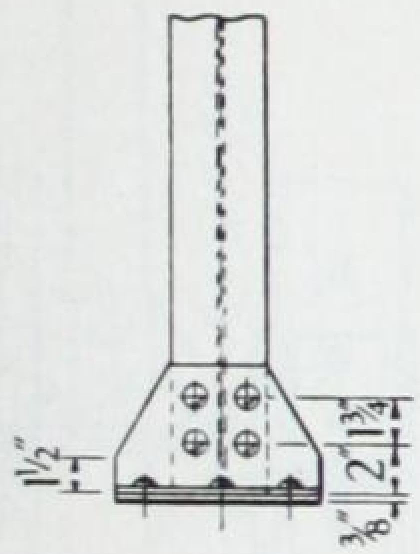
B.F. BEAM, 4″ × 4″ × 15 lb., GREY PROCESS.

For Stanchion Properties and Safe Loads, see pages 84, 85.

Weight of Cap, 17 lb.







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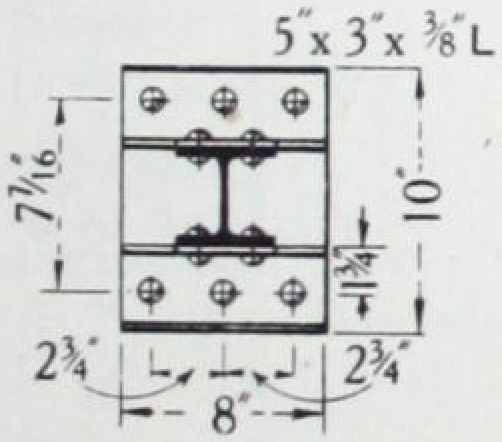


Rivets ⅝″ dia.

Weight of Base, 22 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 9·7 tons, the safe central load for a height of 12 feet, as given on p. 85. Its area, ·56 sq. feet, is sufficient for any good concrete foundation, with or without reinforcement.

CAP. The shear value of the rivets in *each* flange cleat is 7·4 tons.

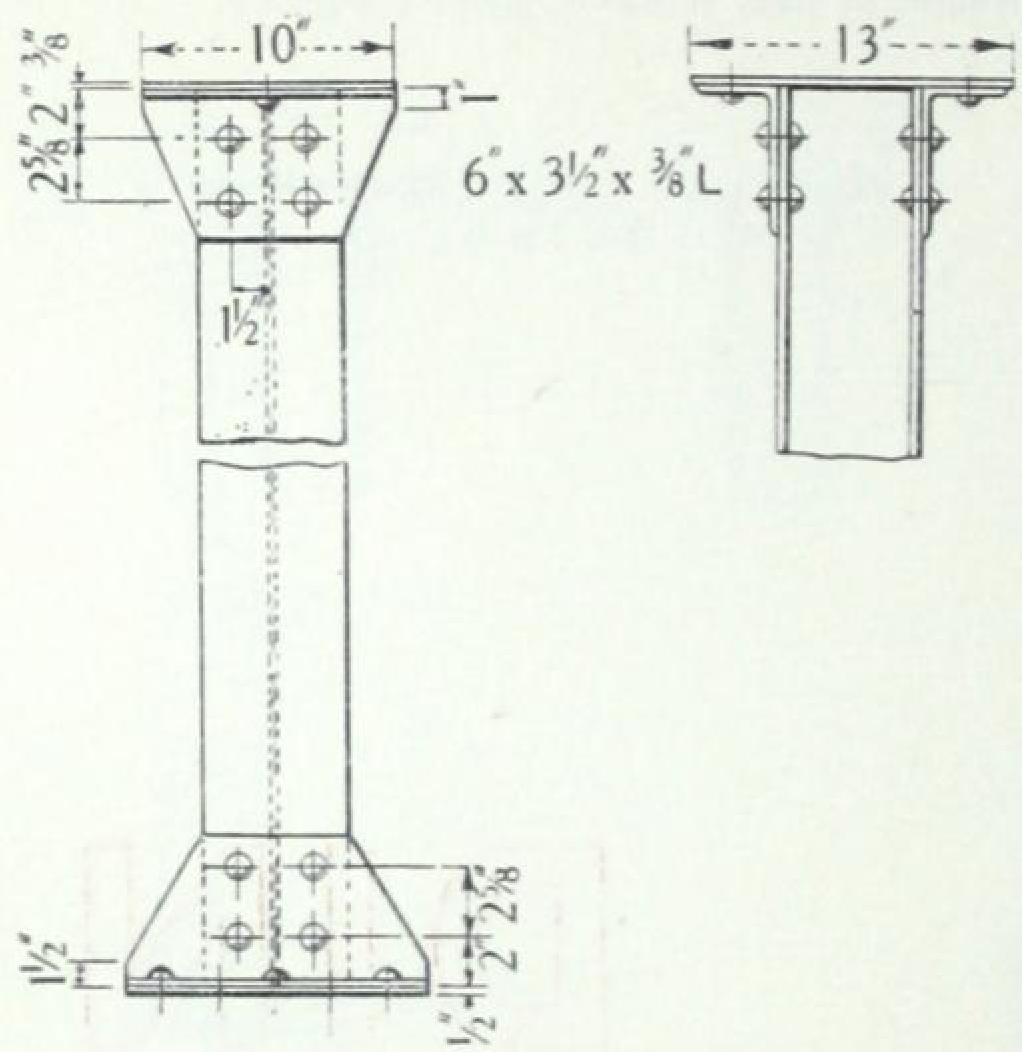
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR

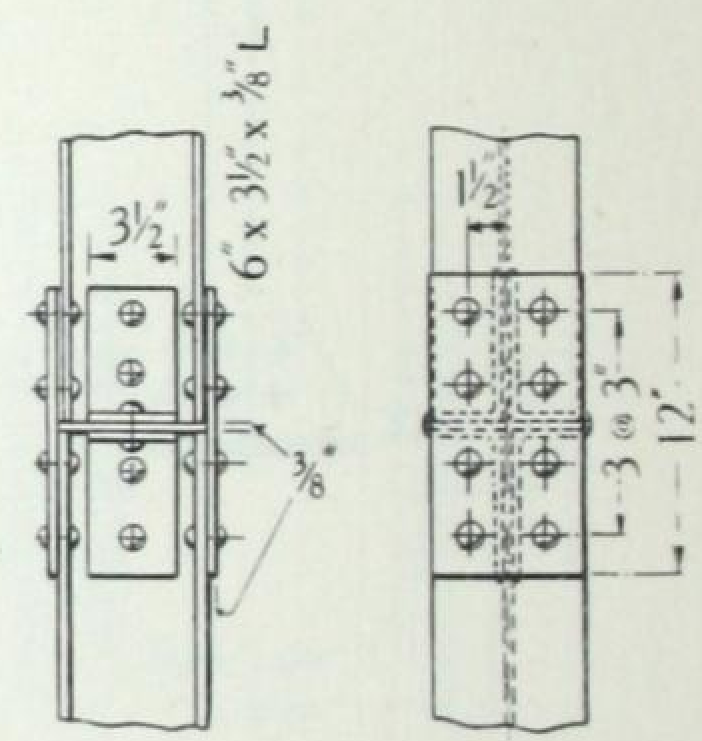
B.F. BEAM, 6″ × 6″ × 18 lb., GREY PROCESS.

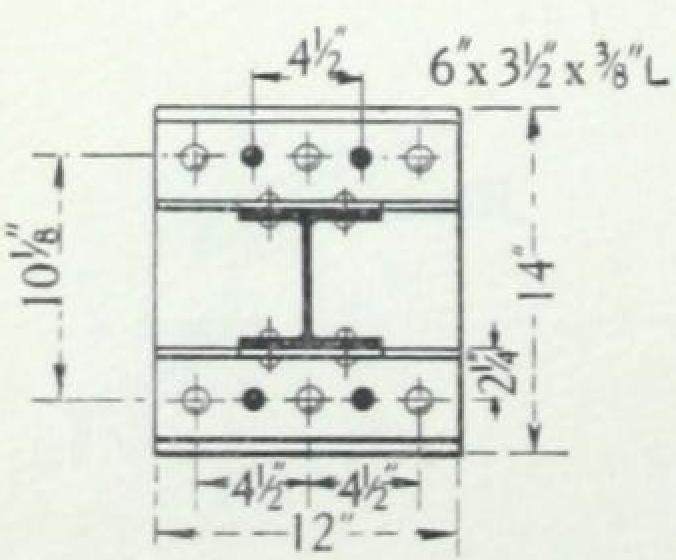
For Welded Alternatives, see page 136.

Weight of Cap, 33 lb.



DIE





Weight of Base, 46 lb.

Weight of joint 41 lb.

Rivets ¾″ dia.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 20 tons, the safe central load for a height of 12 feet, as given on p. 85. Its area, 1·17 sq. feet, is sufficient for any good concrete foundation, with or without reinforcement.

CAP. The shear value of the rivets in *each* flange cleat is 10·6 tons.

SLEEVE JOINT. This is designed to transmit a load of 20 tons. The sizes shown joined are 6″ × 6″ nominal by 18 lb. and 25 lb. respectively.

For further explanation, see page 112.

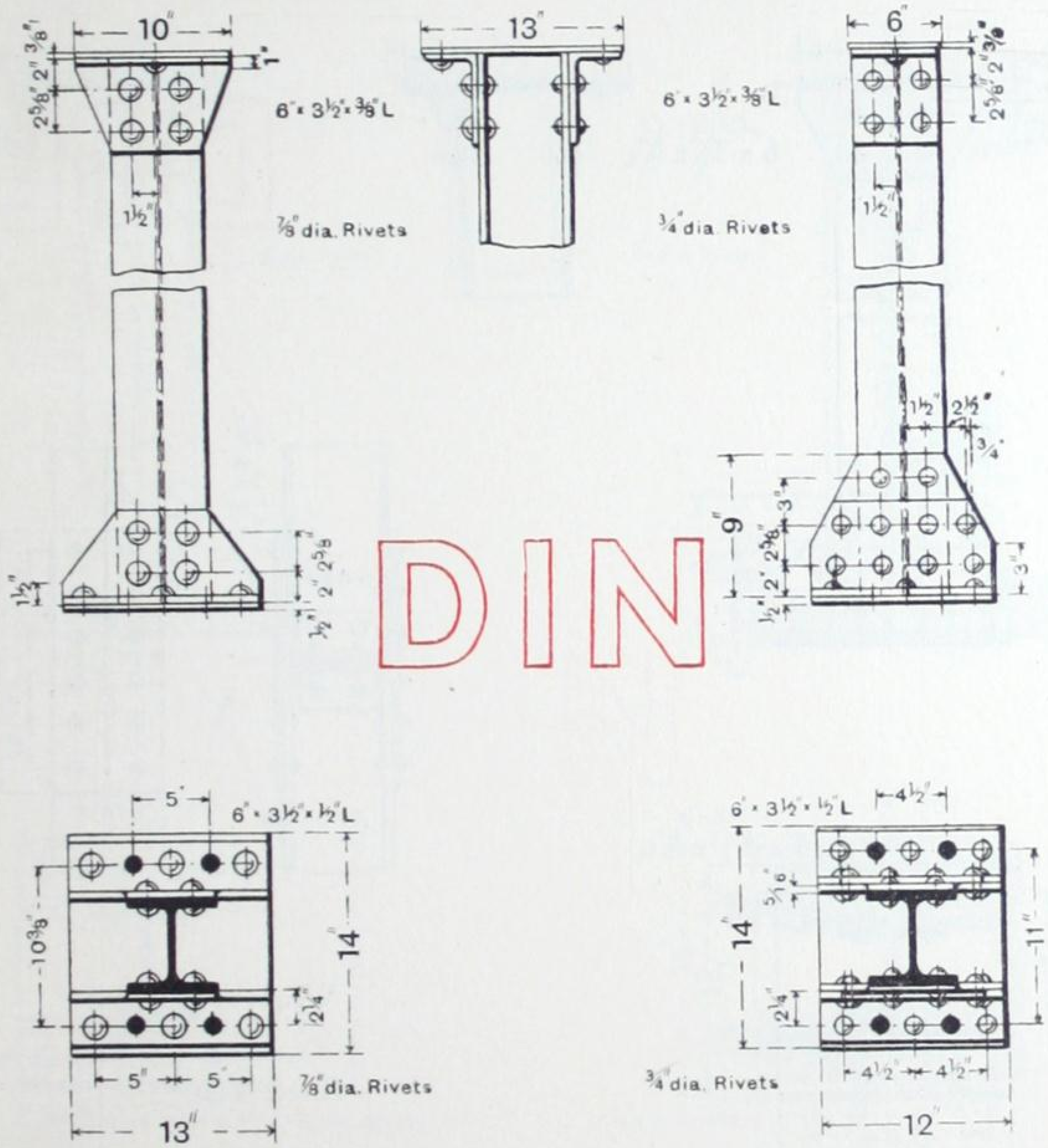
STANDARD STANCHION DETAILS FOR

B.F. BEAM 6″ × 6″ × 25 lb., GREY PROCESS.

For Stanchion Properties and Safe Loads, see pages 84, 85.

HEAVY CAP, Weight : 35 lb.

LIGHT CAP, Weight : 22 lb.



STANDARD BASE, Weight : 59 lb.

ALTERNATIVE BASE, Weight : 77 lb

Scale ¾ inch = 1 foot.

BASES. These are designed to transmit loads up to 29 tons, the safe central load for a height of 12 feet, as given on page 85. Their areas, 1·26 and 1·17 sq. feet respectively, are sufficient for any good concrete foundation, with or without reinforcement.

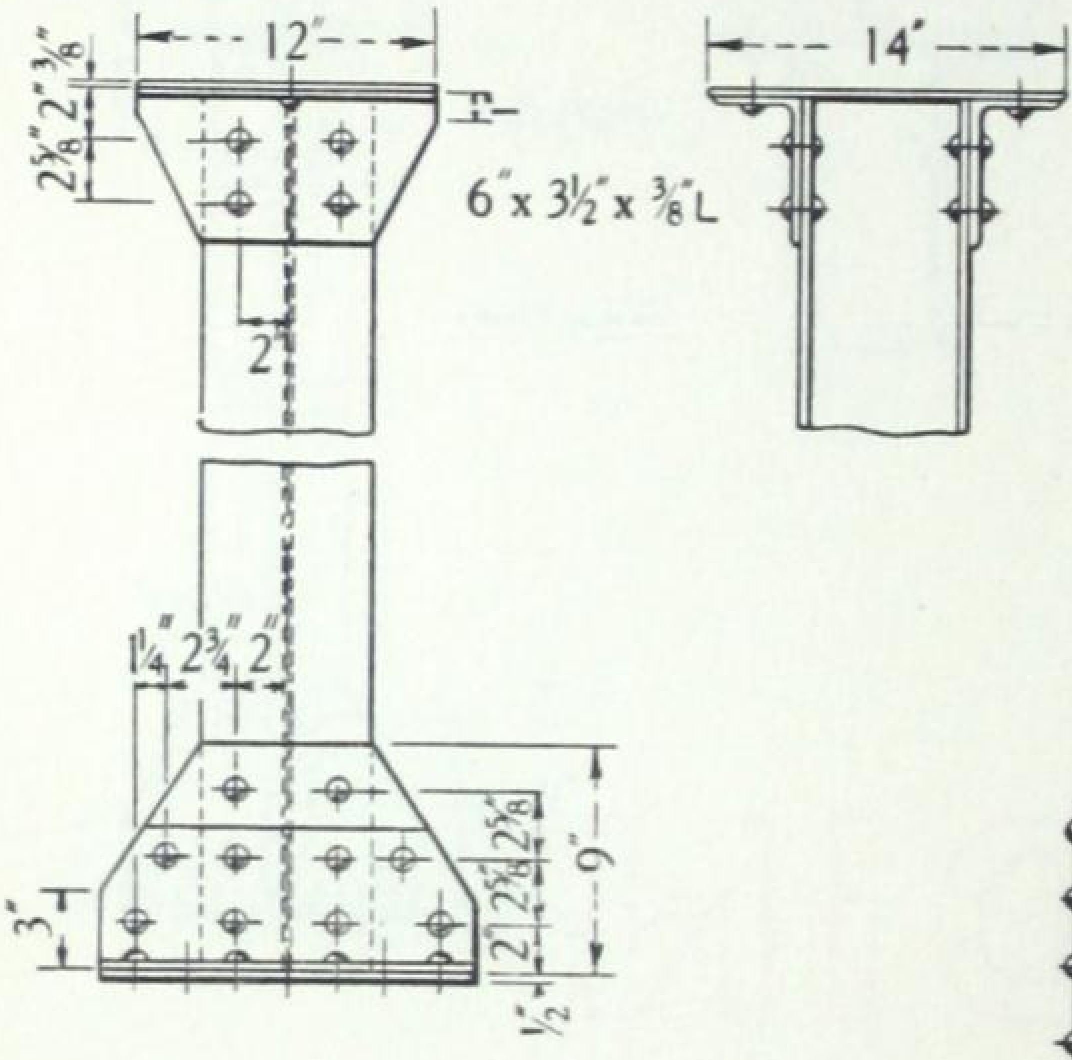
CAPS. The shear value of the rivets in *each* flange cleat is, for the Heavy Cap 14·4 tons; for the Light Cap 10·6 tons.

For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR
B.F. BEAM 7″ × 7″ × 25 lb., GREY PROCESS.

For Welded Alternatives, see page 138.

Weight of Cap, 41 lb.



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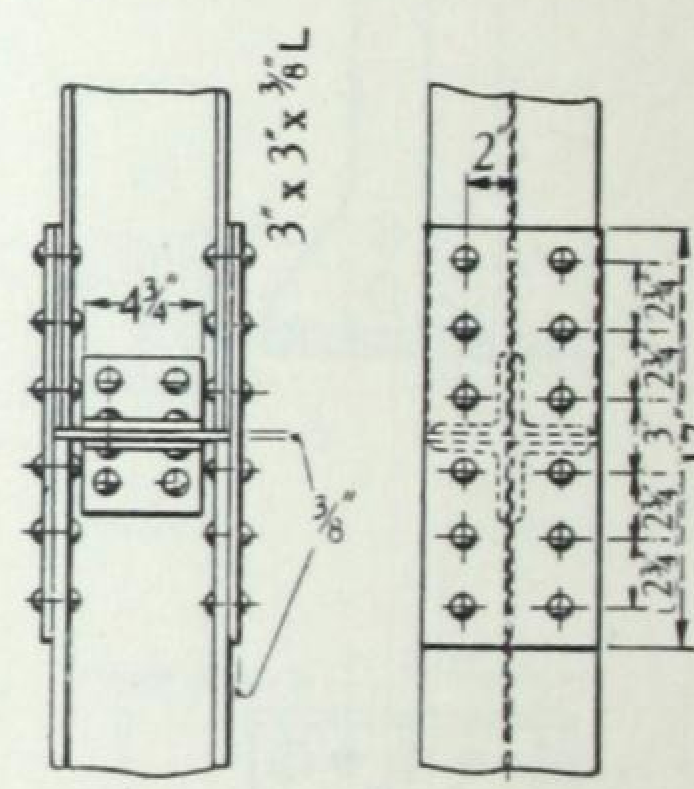
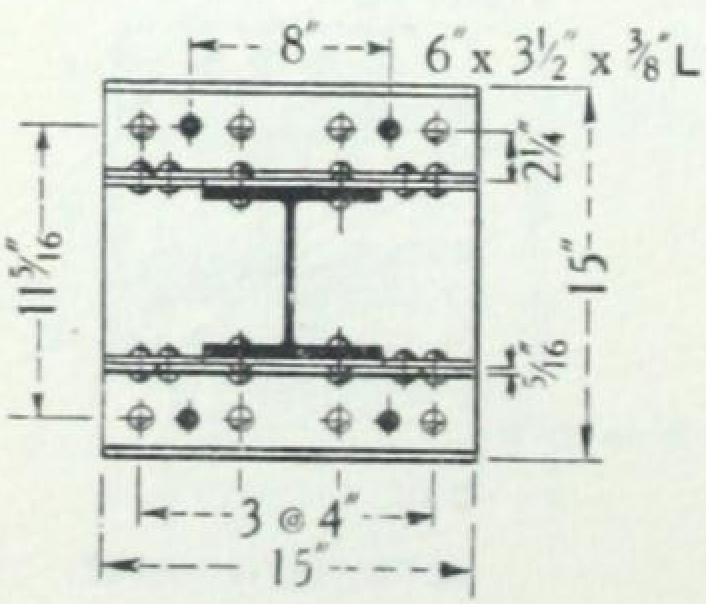




Weight of joint 55 lb.

Rivets ¾″ dia.

Weight of Base, 85 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 34 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·56 sq. feet, is sufficient for a reinforced concrete foundation.

CAP. The shear value of the rivets in *each* flange cleat is 10·6 tons.

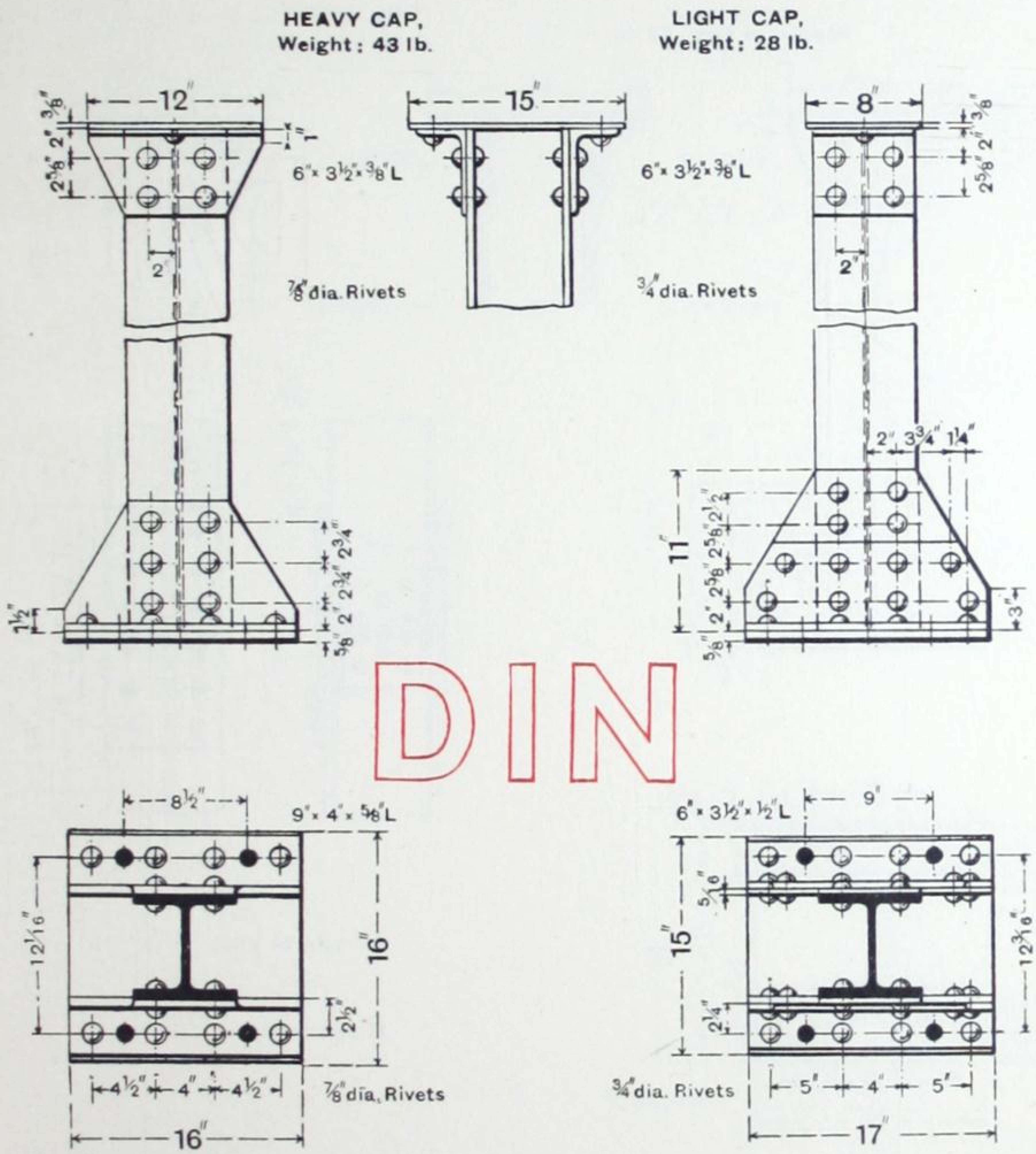
SLEEVE JOINT. This is designed to transmit a load of 34 tons. The sizes shown joined are 7″ × 7″ nominal by 25 lb. and 35 lb. respectively.

For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR

B.F. BEAM 7″ × 7″ × 35 lb., GREY PROCESS.

For Stanchion Properties and Safe Loads, see pages 84, 85.



STANDARD BASE,
Weight: 110 lb.

ALTERNATIVE BASE,
Weight: 121 lb.

Scale ¾ inch = 1 foot

BASES. These are designed to transmit loads up to 50 tons, the safe central load for a height of 12 feet, as given on page 85. Their areas, 1·78 and 1·77 sq. feet respectively, are sufficient for a reinforced concrete foundation.

CAPS. The shear value of the rivets in *each* flange cleat is, for the Heavy Cap 14·4 tons; for the Light Cap 10·6 tons.

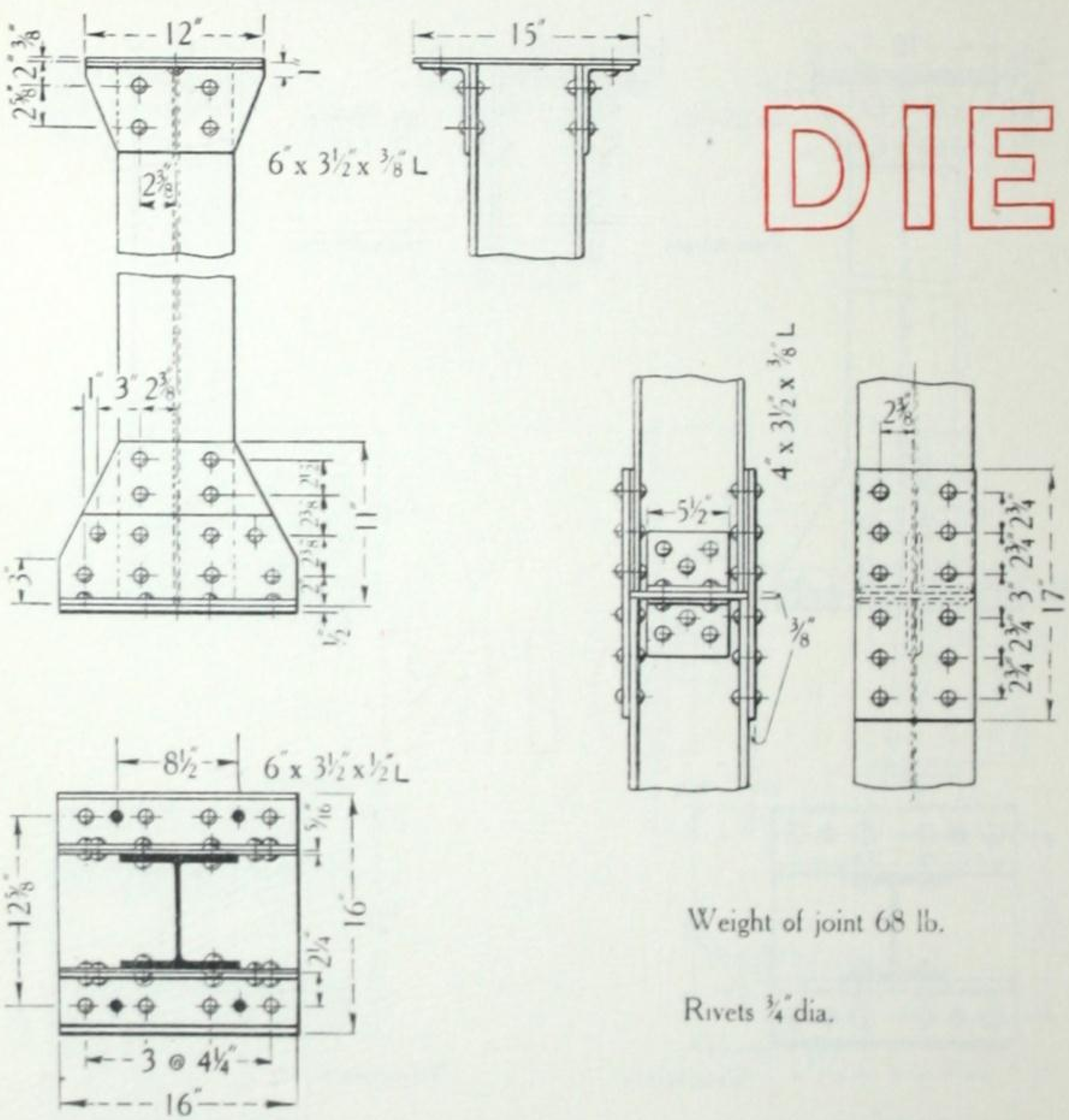
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR

B.F. BEAM 8″ × 8″ × 30 lb., GREY PROCESS.

For Welded Alternatives, see page 140.

Weight of Cap, 42 lb.



Weight of joint 68 lb.

Rivets ¾″ dia.

Weight of Base, 109 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 46 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·78 sq. feet, is sufficient for a reinforced concrete foundation.

CAP. The shear value of the rivets in *each* flange cleat is 10·6 tons.

SLEEVE JOINT. This is designed to transmit a load of 46 tons. The sizes shown joined are 8″ × 8″ nominal by 30 lb. and 44 lb. respectively.

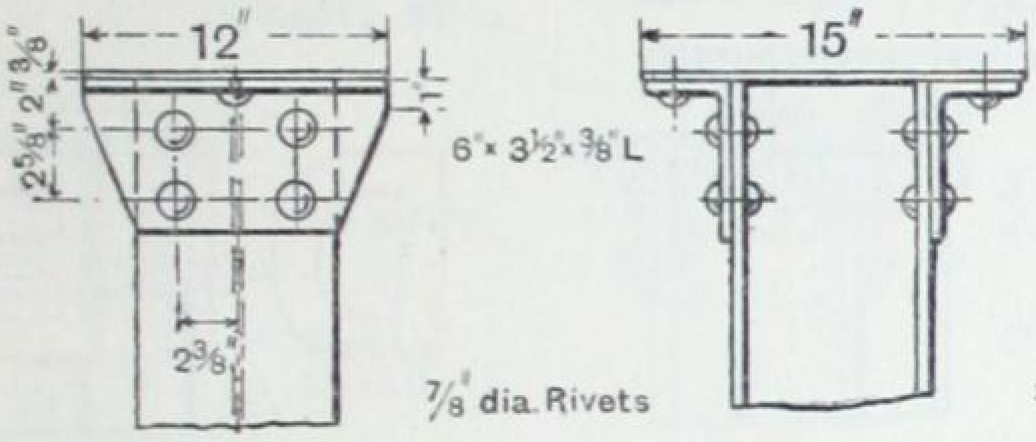
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR

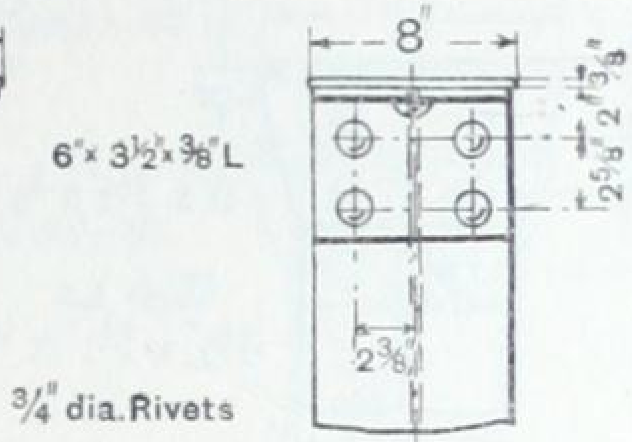
B.F. BEAM 8″ × 8″ × 44 lb., GREY PROCESS.

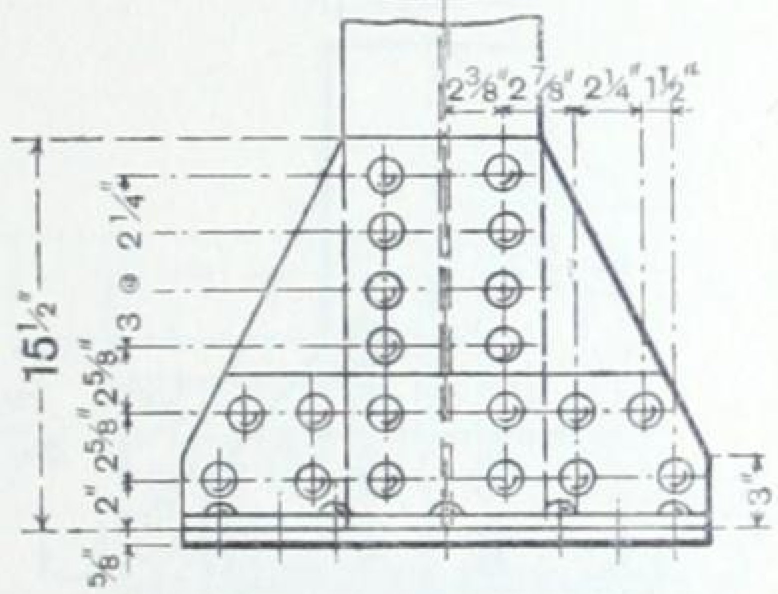
For Stanchion Properties and Safe Loads, see pages 84, 85.

HEAVY CAP,
Weight: 44 lb.



LIGHT CAP,
Weight: 30 lb.





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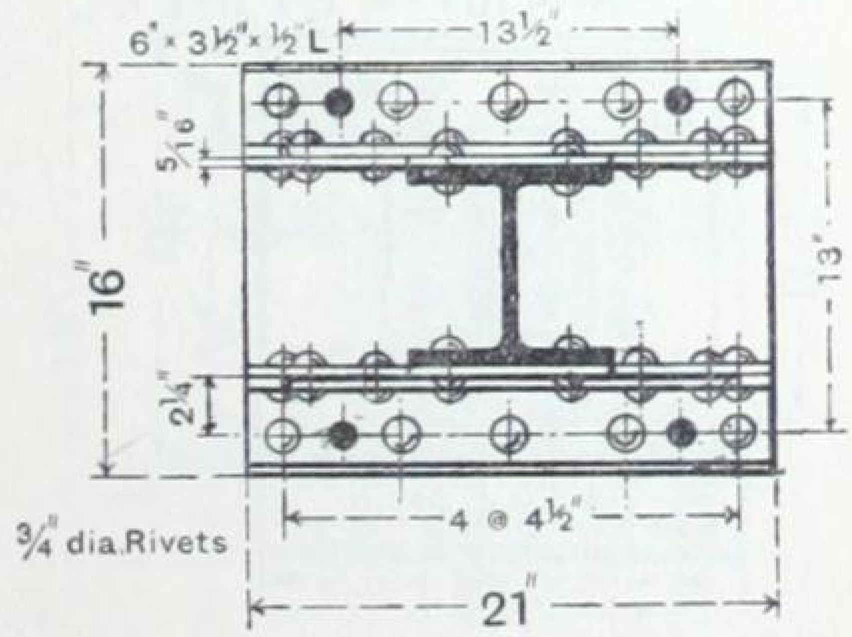

STANDARD BASE,
Weight: 147 lb.

ALTERNATIVE BASE,
Weight: 157 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 68 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 2·33 sq. feet, is sufficient for a reinforced concrete foundation.

CAPS. The shear value of the rivets in *each* flange cleat is, for the Heavy Cap 14·4 tons; for the Light Cap 10·6 tons.

For further explanation, see page 112.

Poles, Piles.
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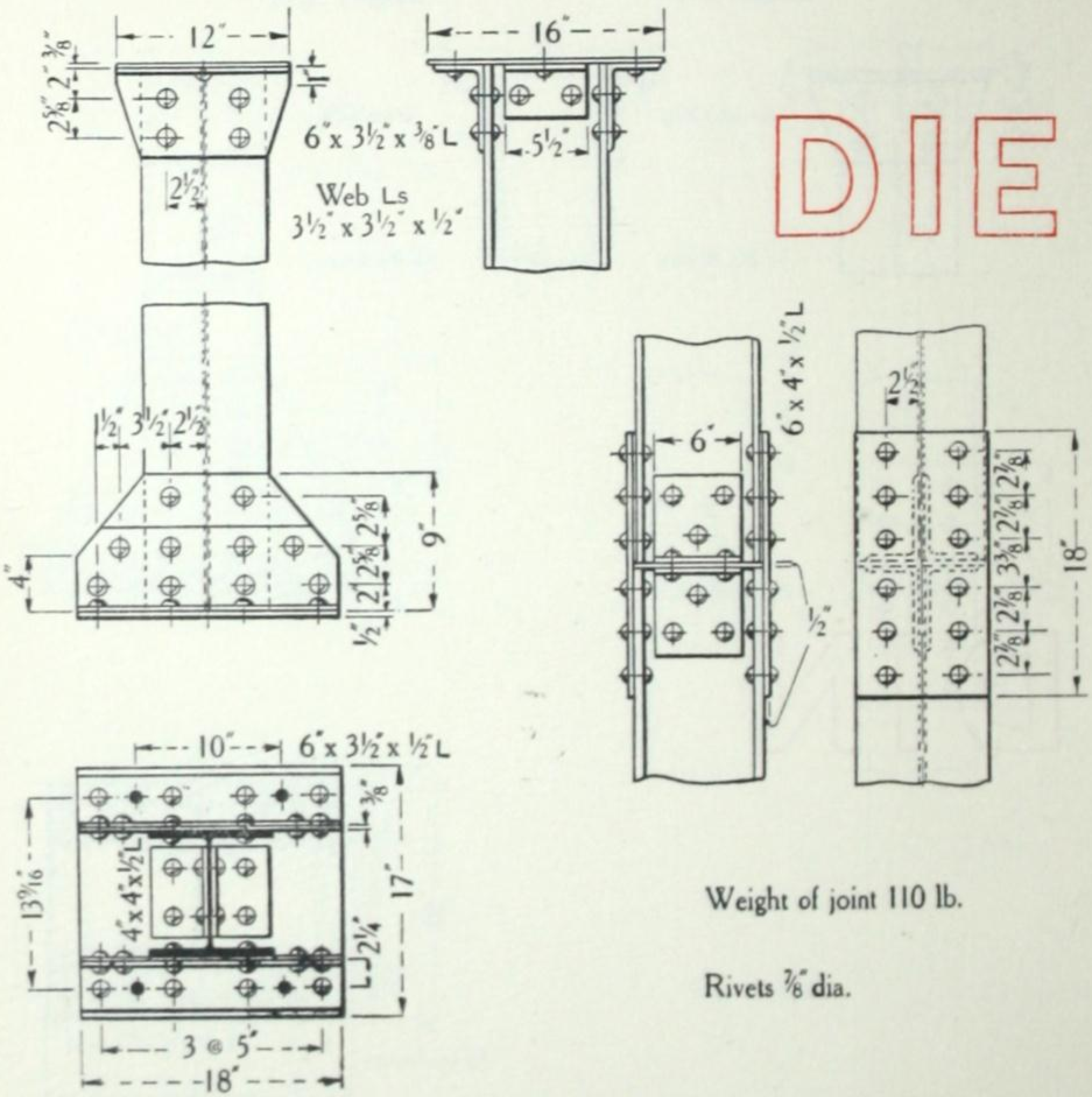
Rivets, Bolts.
Roofs, Concrete
Welding
Plates, Inertia.
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

STANDARD STANCHION DETAILS FOR
B.F. BEAM $8\frac{1}{2}'' \times 8\frac{1}{2}'' \times 34\frac{1}{2}$ lb., GREY PROCESS.

For Welded Alternatives, see page 142.

Weight of Cap, 56 lb.



Weight of joint 110 lb.

Rivets ⅞" dia.

Weight of Base, 153 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 56 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 2·12 sq. feet, is sufficient for a reinforced concrete foundation.

CAP. The shear value of the rivets in *each* flange cleat is 14·4 tons.

SLEEVE JOINT. This is designed to transmit a load of 56 tons. The sizes shown joined are $8\frac{1}{2}'' \times 8\frac{1}{2}''$ nominal by $34\frac{1}{2}$ lb. and 48 lb. respectively.

For further explanation, see page 112.

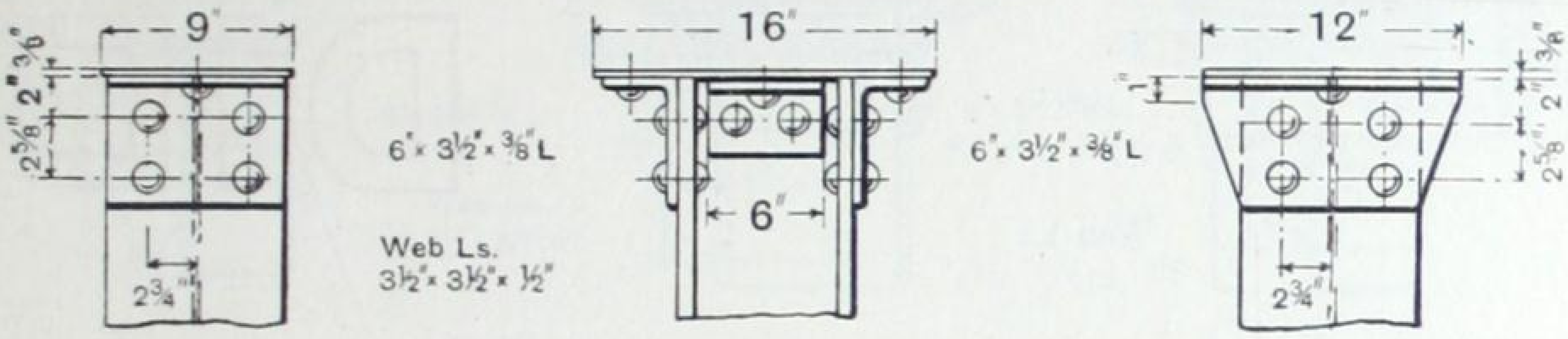
STANDARD STANCHION DETAILS FOR

B.F. BEAM $8\frac{1}{2}'' \times 8\frac{1}{2}'' \times 48$ lb., GREY PROCESS.

For Stanchion Properties and Safe Loads, see pages 84, 85.

LIGHT CAP,
Weight: 47 lb.

HEAVY CAP,
Weight: 57 lb.



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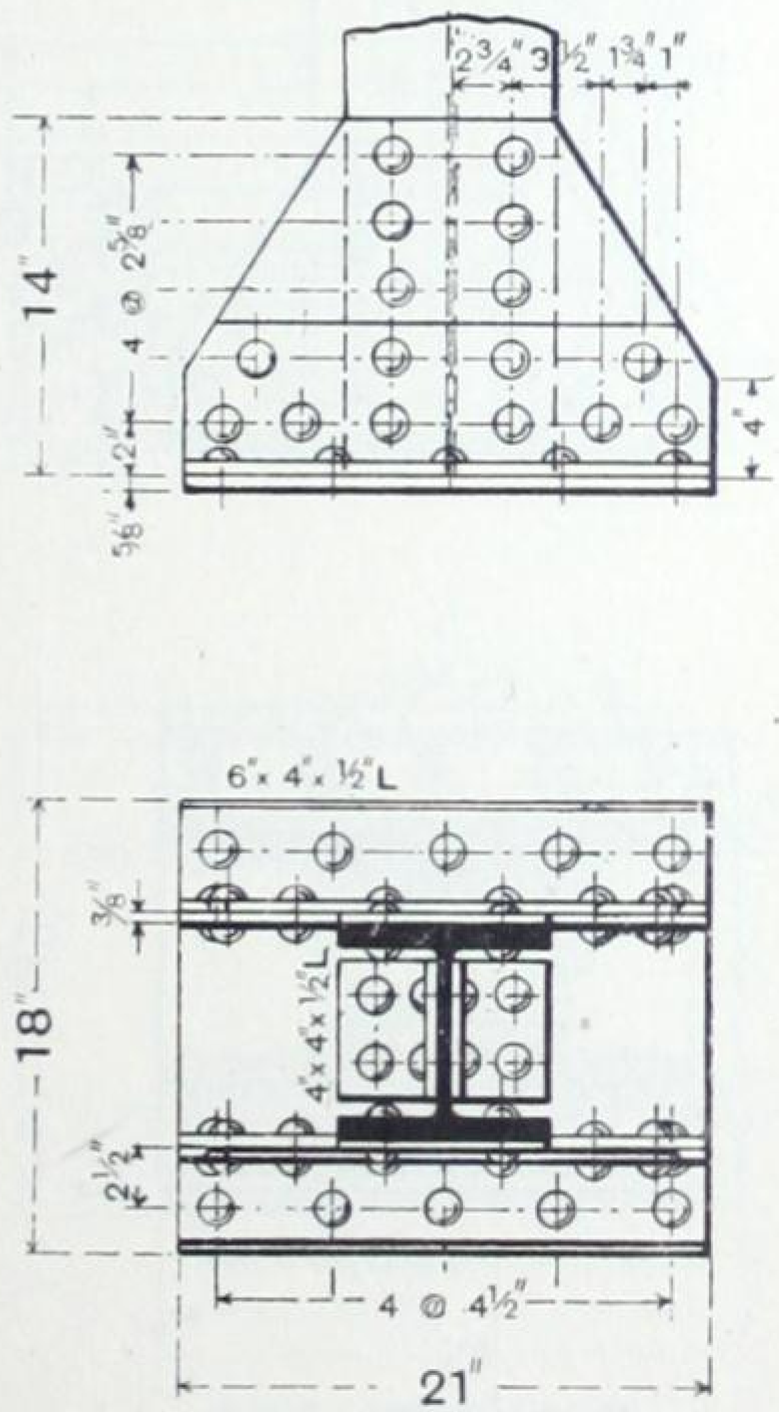


STANDARD BASE,
Weight: 200 lb.

Rivets $\frac{7}{8}''$ dia.

Scale $\frac{3}{4}$ inch = 1 foot.

BASE. This is designed to transmit loads up to 79 tons, the safe central load for a height of 12 feet, as given on page 85. Its effective area, 2·63 sq. feet, is sufficient on reinforced concrete for loads up to 68 tons: for greater loads a grillage foundation is indicated.

CAPS. The shear value of the rivets in *each* flange cleat is, for the Heavy Cap 14·4 tons; for the Light Cap 14·4 tons.

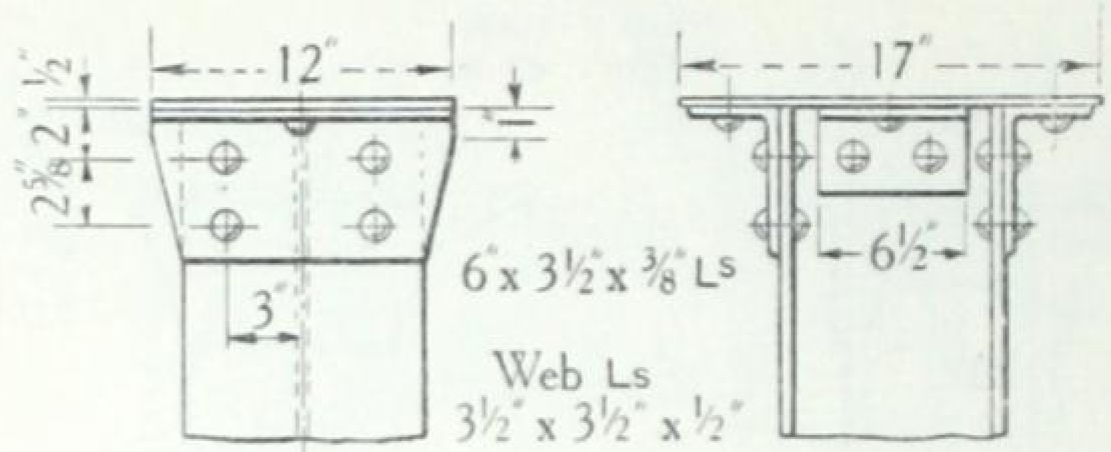
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR

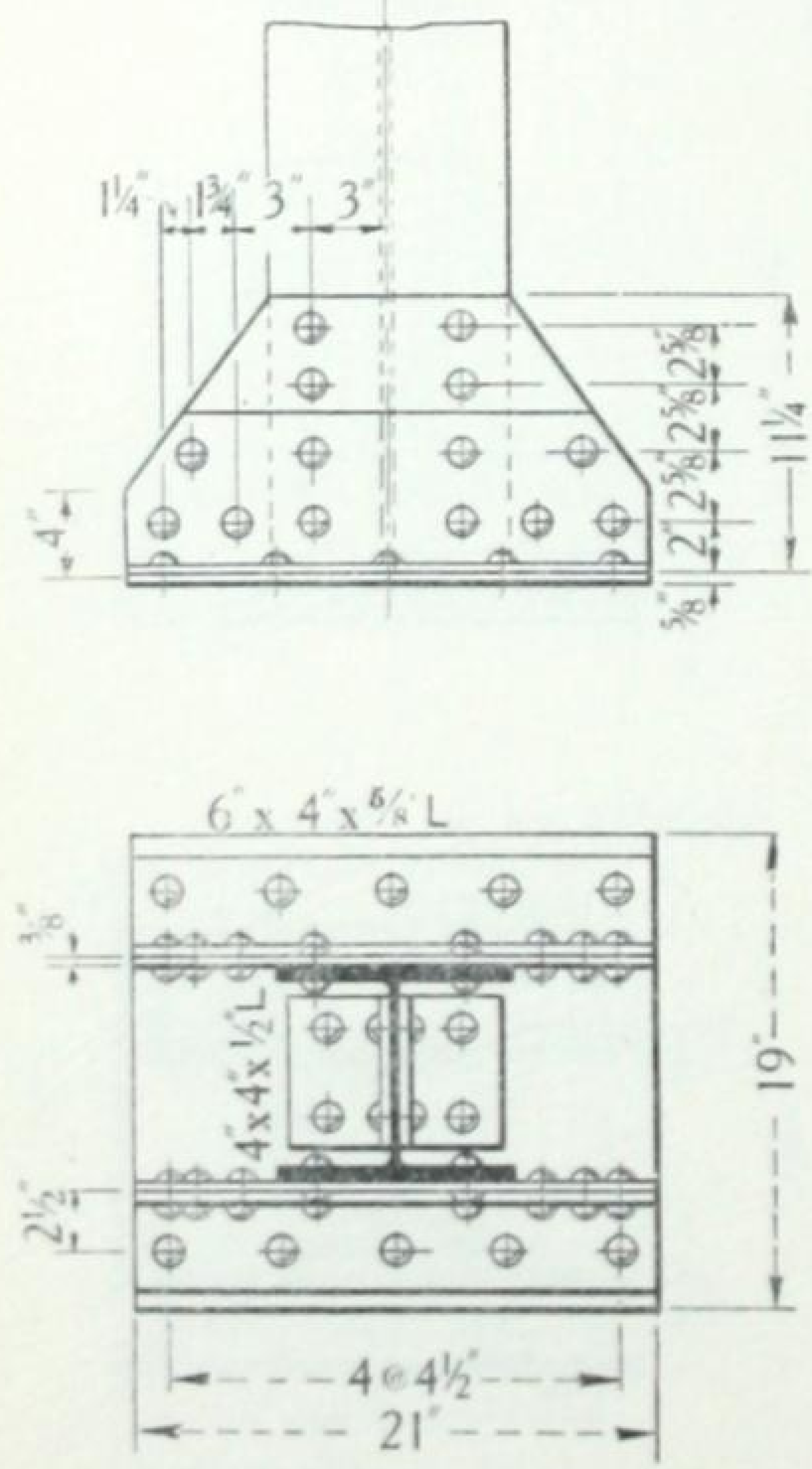
BEAM 10″ × 10″ × 44 lb., GREY PROCESS.

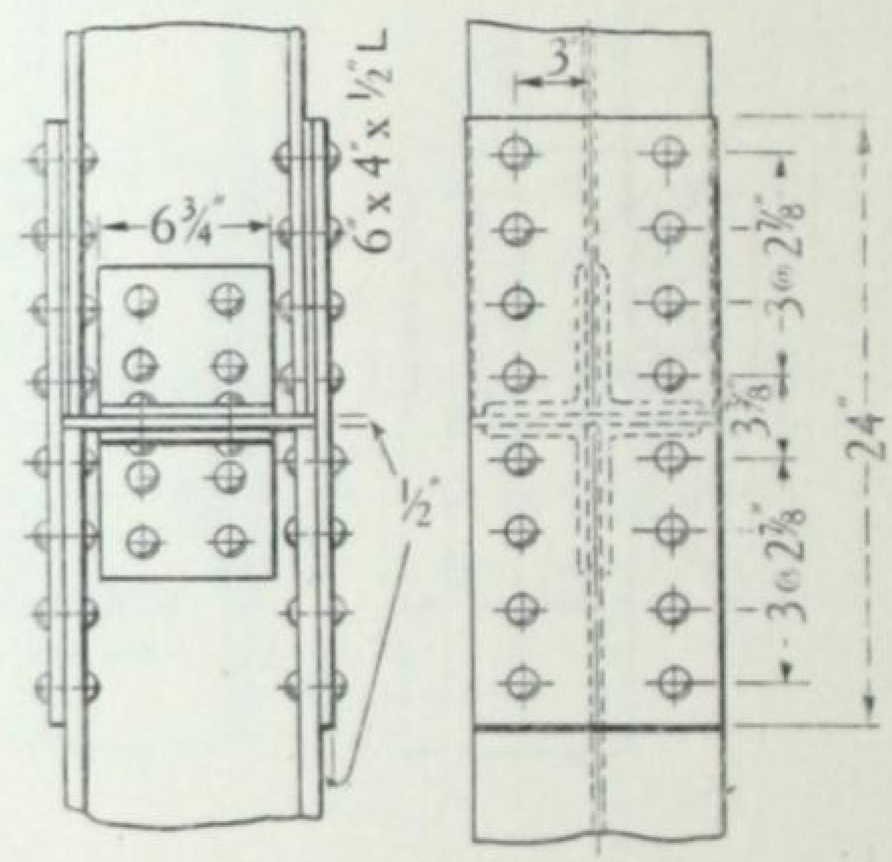
For Welded Alternatives, see page 144. For Slab bases, see page 151.

Weight of Cap, 68 lb.



DIE





Weight of joint 148 lb.

Rivets ⅞″ dia.

Weight of Base, 208 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 77 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 2·77 sq. feet, is sufficient for a reinforced concrete foundation.

CAP. The shear value of the rivets in *each* flange cleat is 14·4 tons.

SLEEVE JOINT. This is designed to transmit a load of 77 tons. The sizes shown joined are 10″ × 10″ nominal by 44 lb. and 61 lb. respectively.

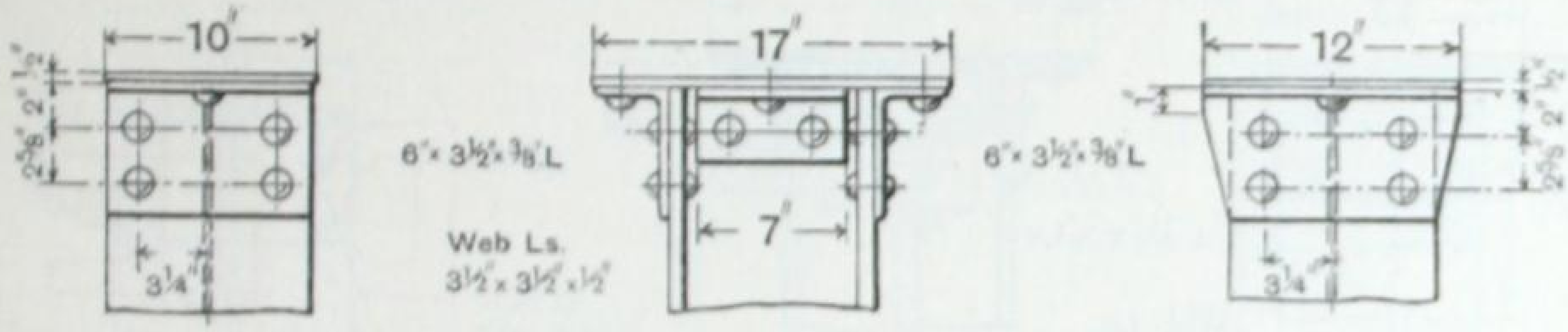
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR
B.F. BEAM 10″ × 10″ × 61 lb., GREY PROCESS.

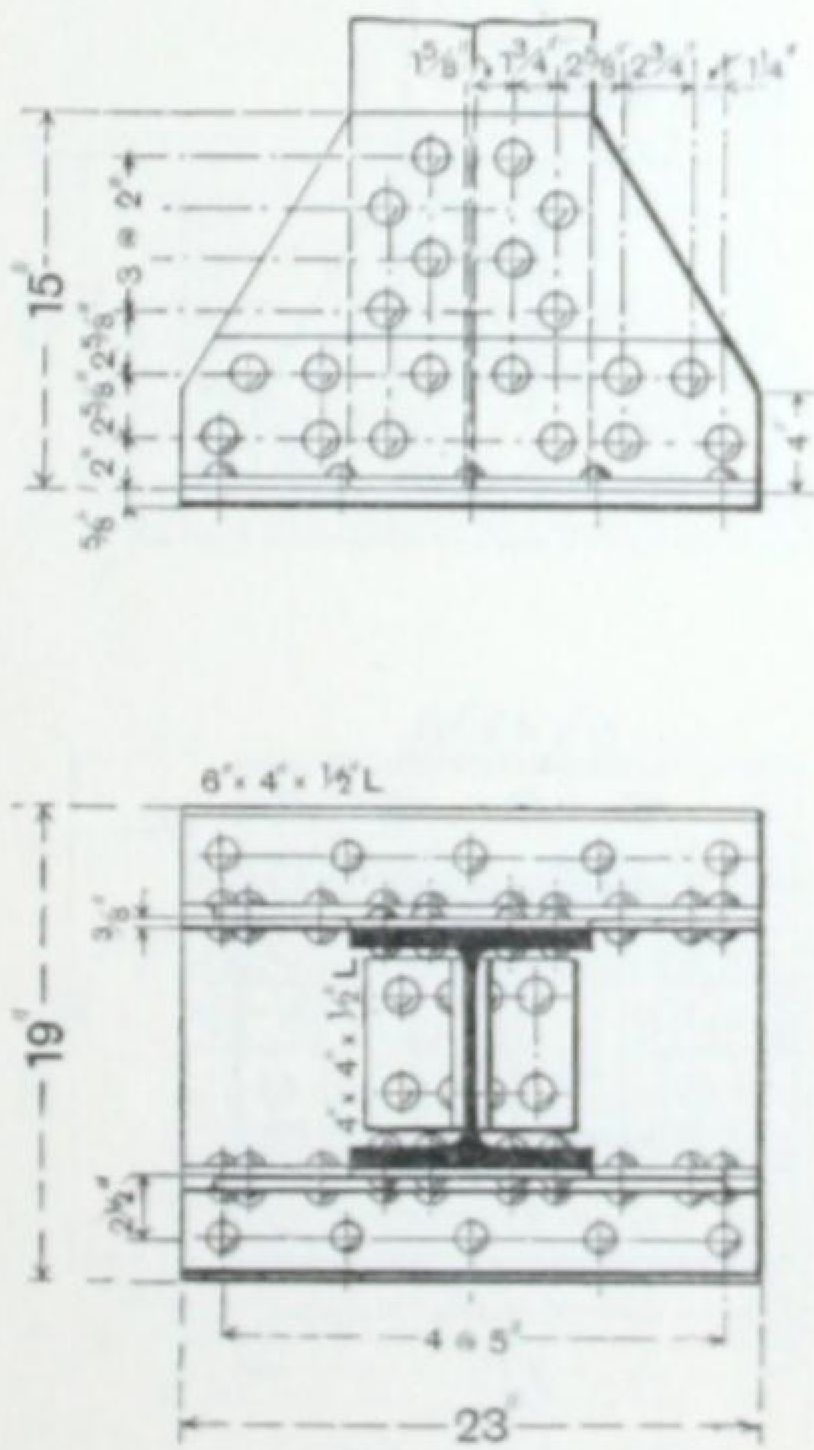
For Stanchion Properties and Safe Loads, see pages 8[illegible], 87.

LIGHT CAP.
Weight : 61 lb.

HEAVY CAP.
Weight : 69 lb.



DIN



STANDARD BASE.
Weight : 231 lb.

Rivets ⅞″ dia.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 108 tons, the safe central load for a height of 12 feet, as given on page 87. Its effective area, 3·03 sq. feet, is sufficient on reinforced concrete for loads up to 78 tons ; for greater loads a grillage foundation is indicated.

CAPS. The shear value of the rivets in *each* flange cleat is 14·4 tons.

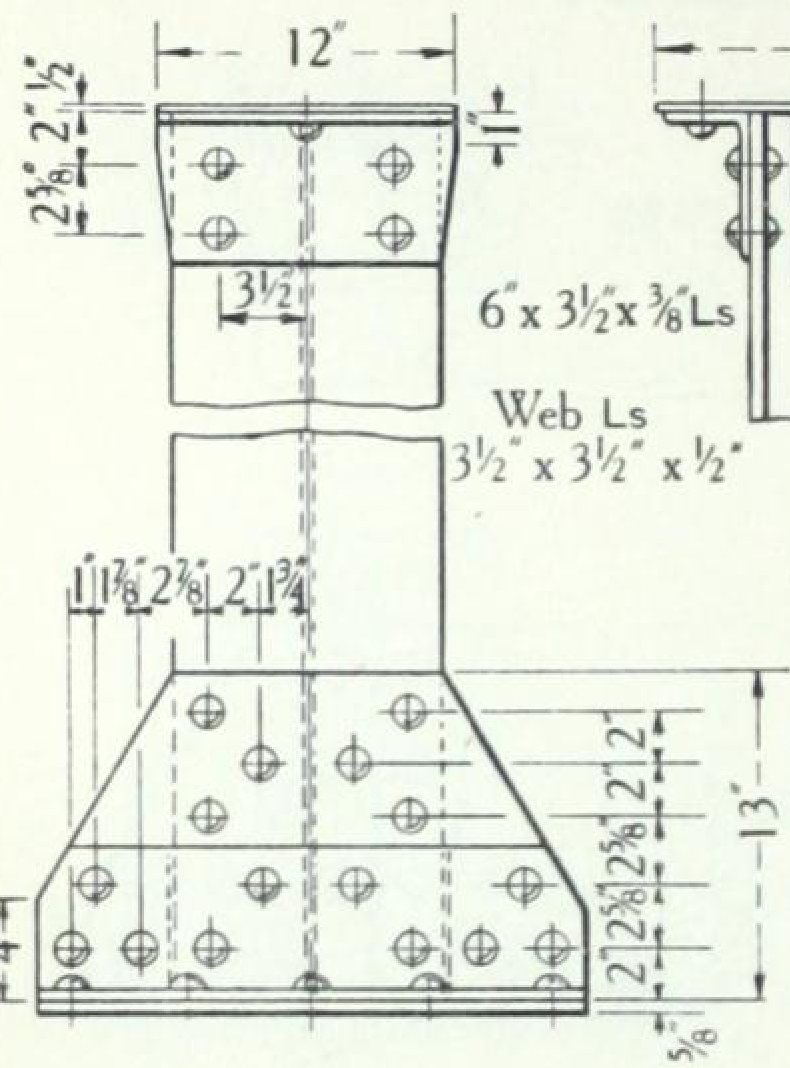
For further explanation, see page 112.

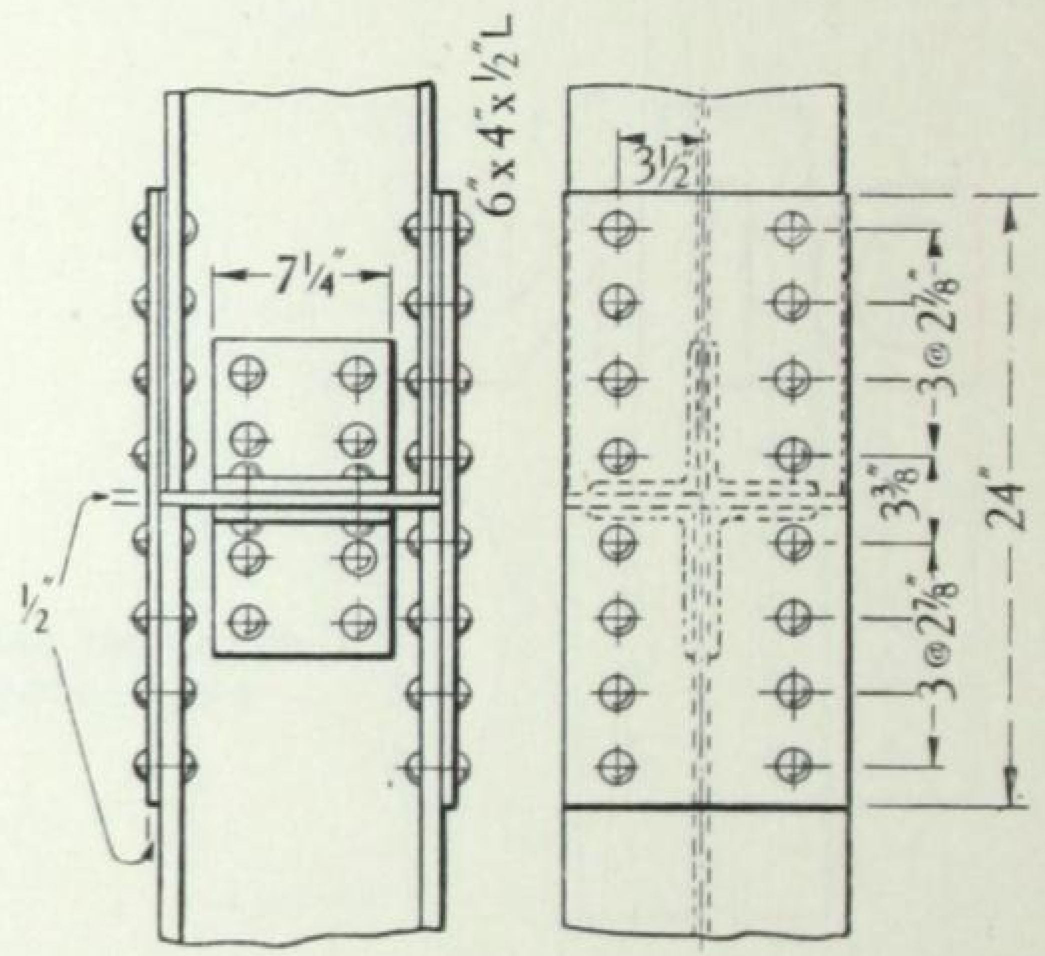
STANDARD STANCHION DETAILS FOR

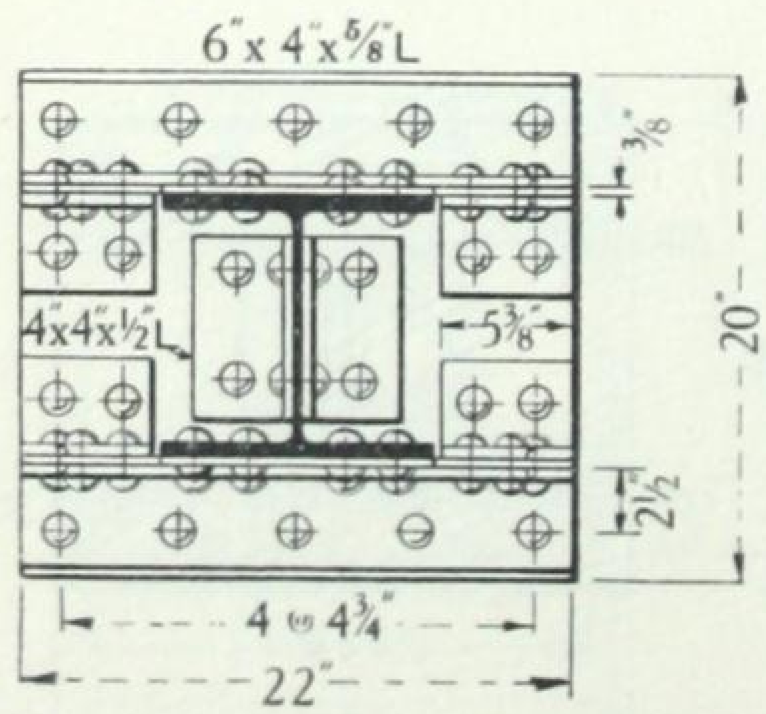
B.F. BEAM 11″ × 11″ × 51½ lb., GREY PROCESS.

For Welded Alternatives, see page 146. For Slab bases, see page 151.

Weight of Cap, 70 lb.







Weight of joint 167 lb.

Rivets ⅞" dia.

Weight of Base, 247 lb.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 94 tons, the safe central load for a height of 12 feet, as given on page 87. Its effective area is sufficient, on reinforced concrete, for loads up to 83 tons (500 lb. per sq. inch); for greater loads, a grillage foundation is indicated.

CAP. The shear value of the rivets in *each* flange cleat is 14·4 tons.

SLEEVE JOINT. This is designed to transmit a load of 94 tons. The sizes shown joined are 11″ × 11″ nominal by 51½ lb. and 76 lb. respectively.

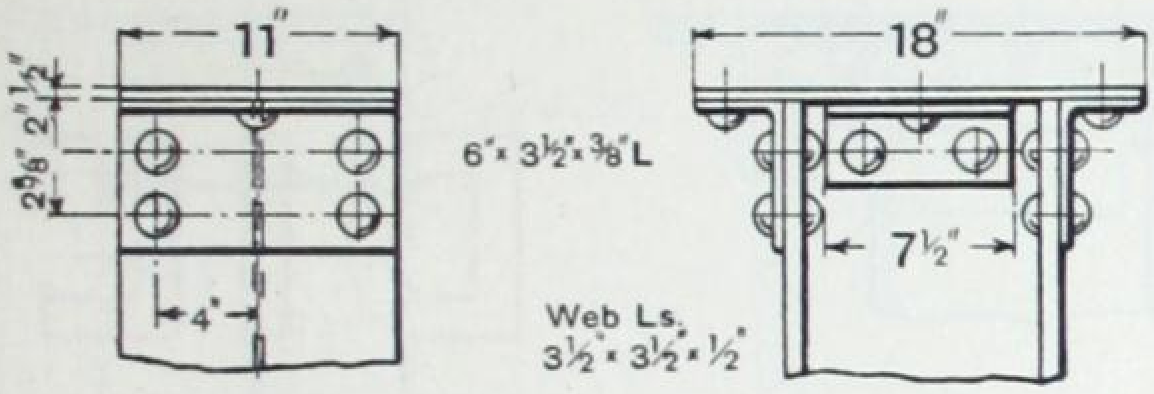
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR

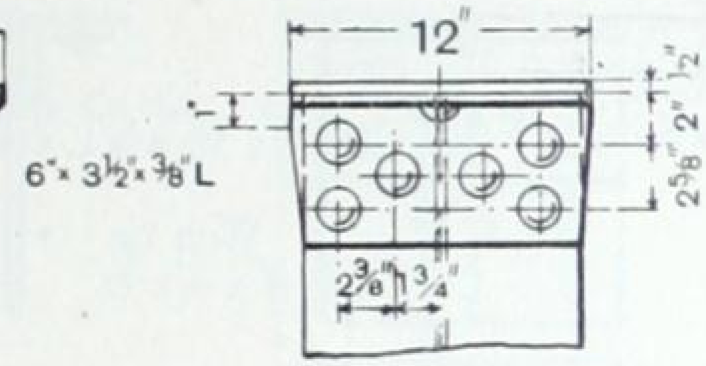
B.F. BEAM 11″ × 11″ × 76 lb., GREY PROCESS.

For Stanchion Properties and Safe Loads, see pages 86, 87.

LIGHT CAP,
Weight: 71 lb.

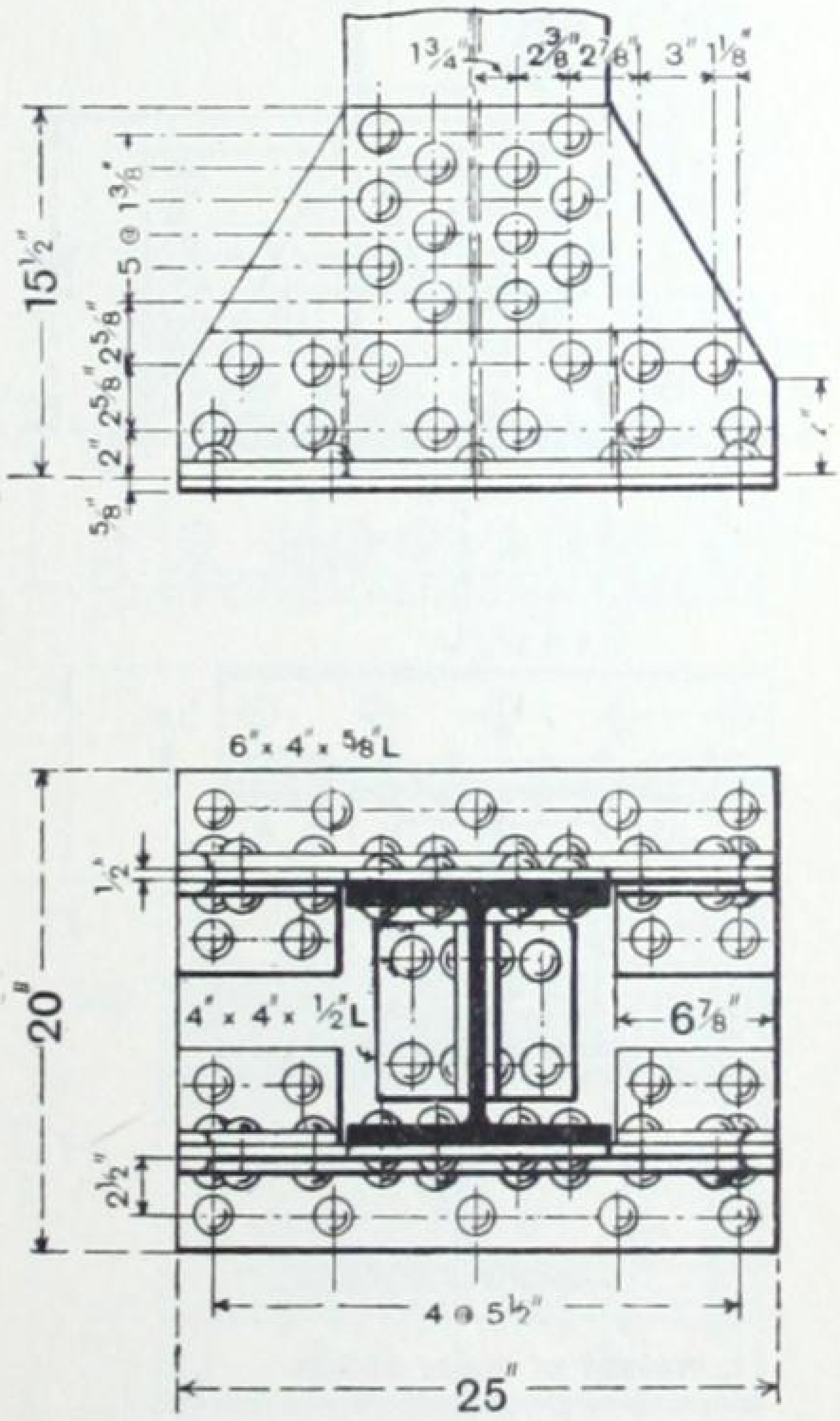


HEAVY CAP,
Weight: 77 lb.



DIN

STANDARD BASE
Weight: 343 lb.



Rivets ⅞″ dia.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 139 tons, the safe central load for a height of 12 feet, as given on page 87. Its effective area is sufficient, on reinforced concrete, for loads up to 102 tons (500 lb. per sq. inch); for greater loads, a grillage foundation is indicated.

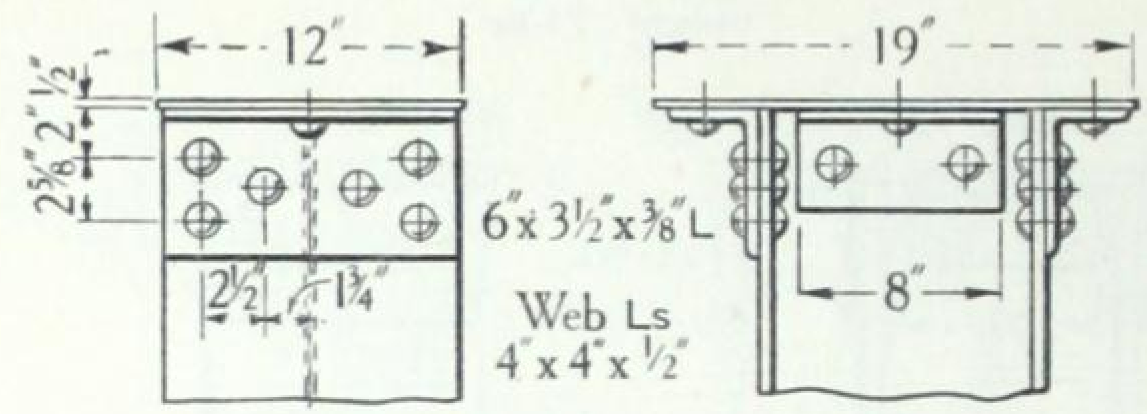
CAPS. The shear value of the rivets in *each* flange cleat is, for the Heavy Cap 21·7 tons; for the Light Cap 14·4 tons.

For further explanation, see page 112.

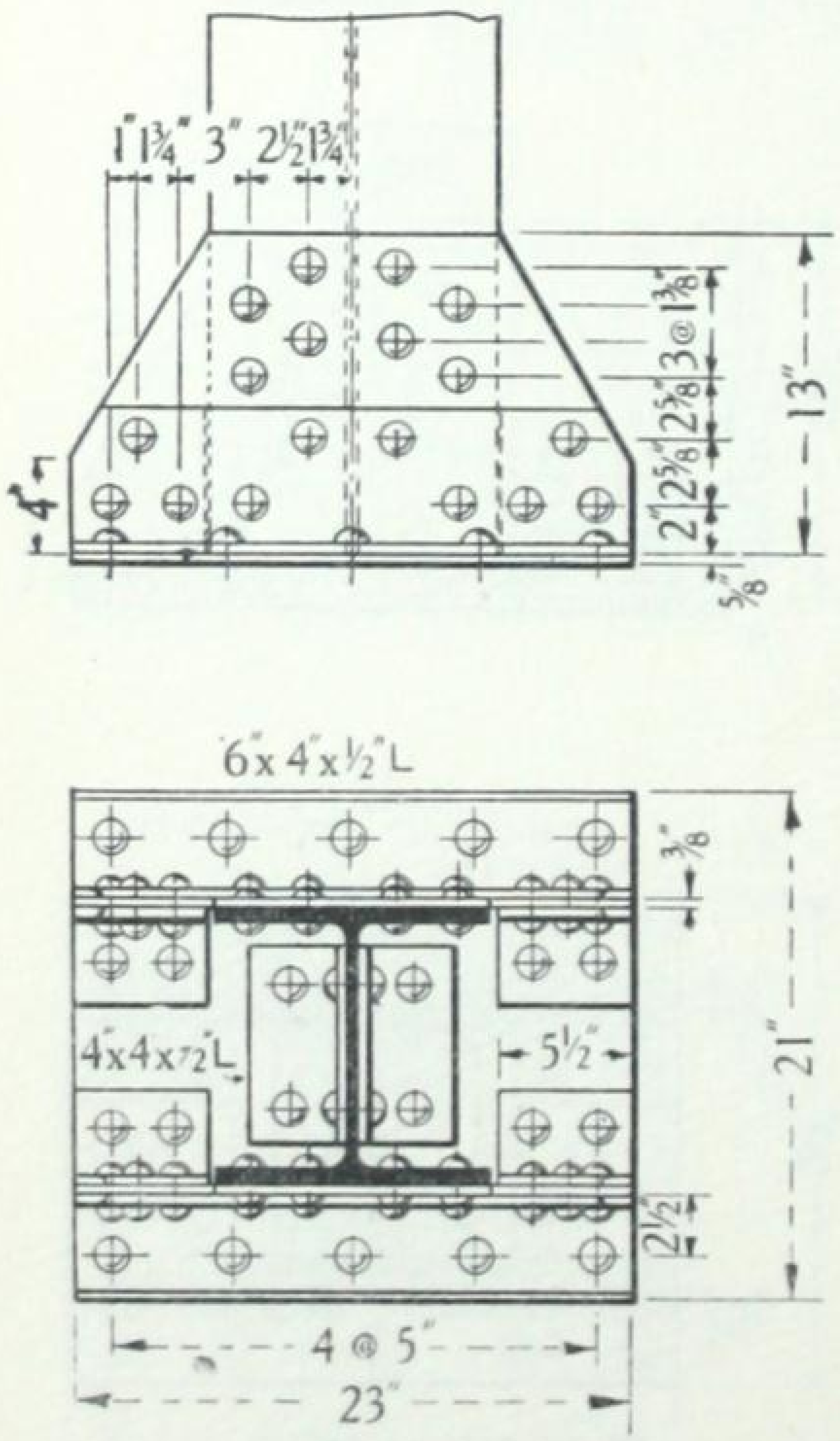
STANDARD STANCHION DETAILS FOR
B.F. BEAM 12″ × 12″ × 59 lb., GREY PROCESS.

For Welded Alternatives, see page 148. For Slab bases, see page 151.

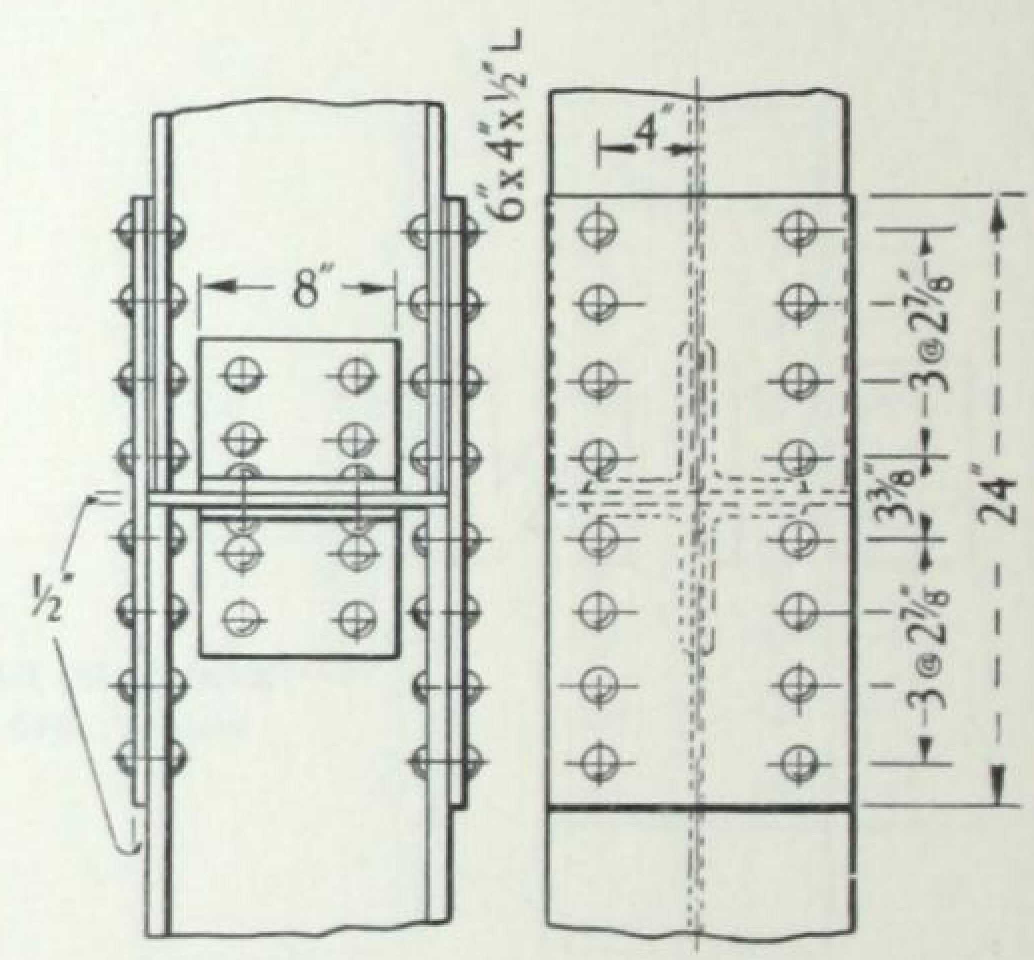
Weight of Cap, 77 lb.



DIE



Weight of Base, 264 lb.



Weight of joint 177 lb.

Rivets ⅞″ dia.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 110 tons, the safe central load for a height of 12 feet, as given on page 87. Its effective area is sufficient, on reinforced concrete, for loads up to 90 tons (500 lb. per sq. inch); for greater loads, a grillage foundation is indicated.

CAP. The shear value of the rivets in *each* flange cleat is 21·7 tons.

SLEEVE JOINT. This is designed to transmit a load of 110 tons. The sizes shown joined are 12″ × 12″ nominal by 59 lb. and 81 lb. respectively.

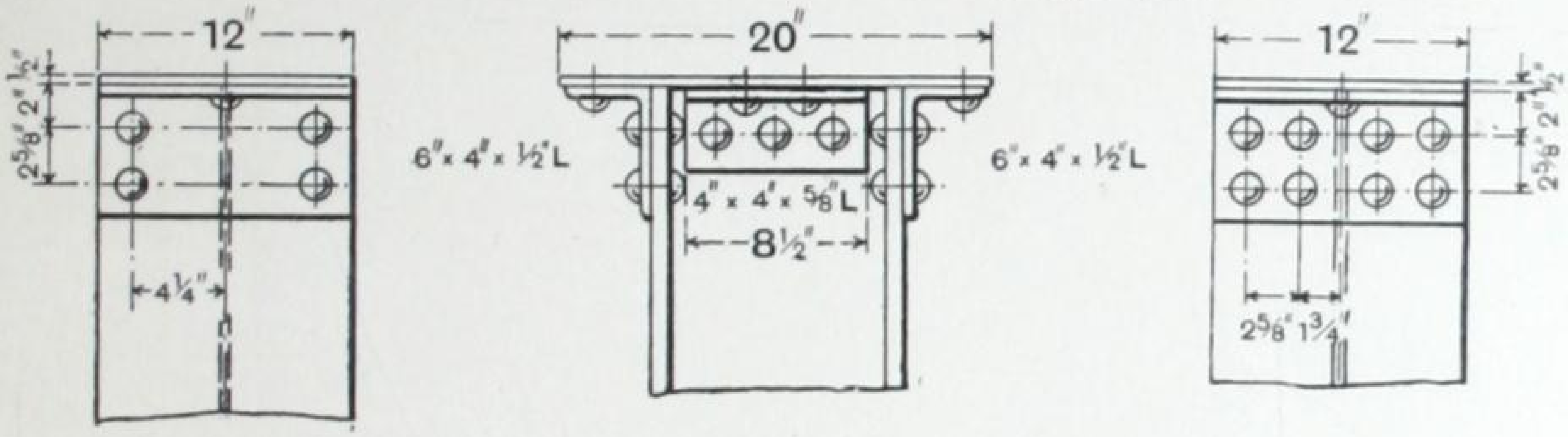
For further explanation, see page 112.

STANDARD STANCHION DETAILS FOR
B.F. BEAM 12″ × 12″ × 81 lb., GREY PROCESS.

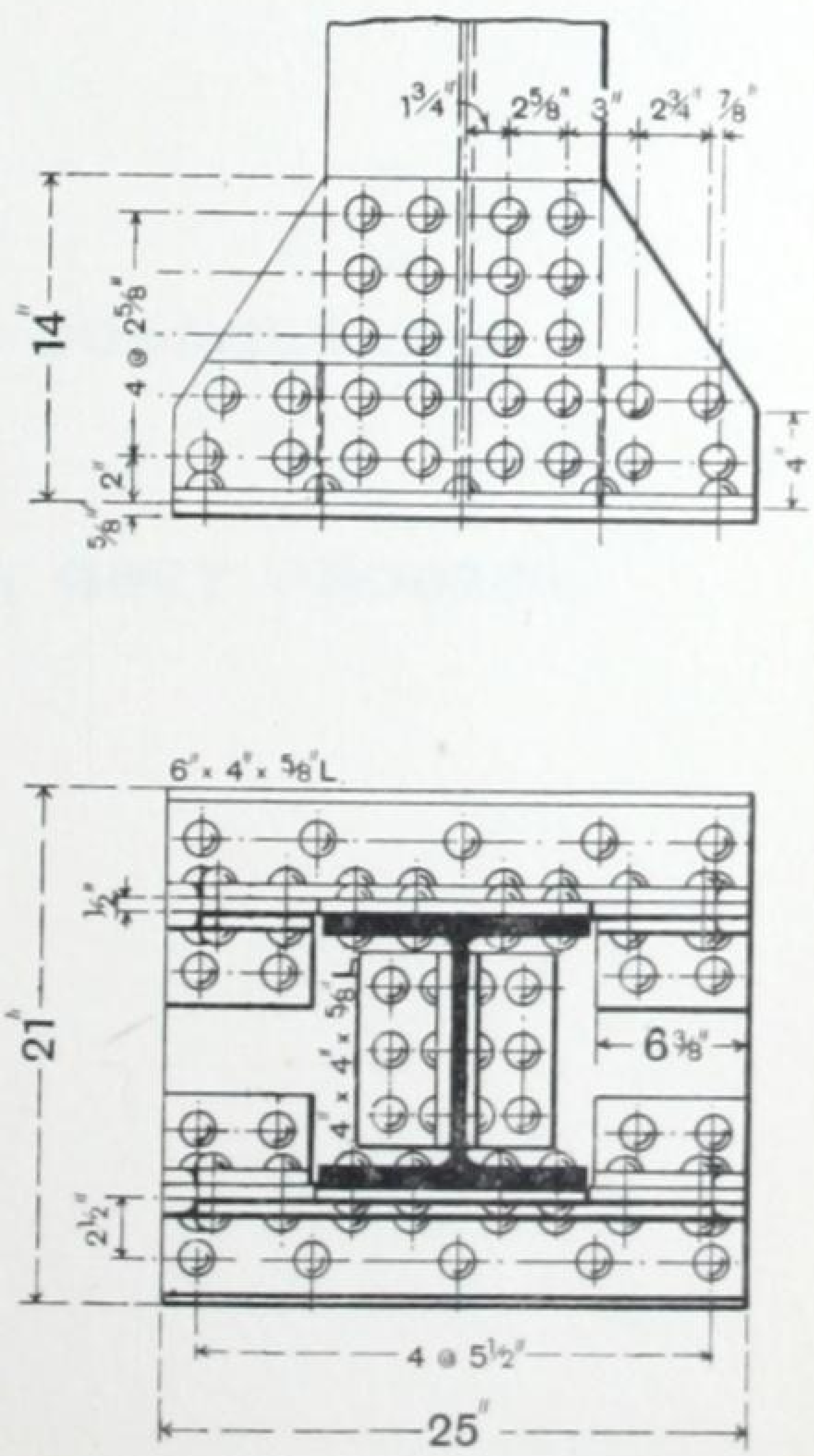
For Stanchion Properties and Safe Loads, see pages 86, 87.

LIGHT CAP,
Weight : 94 lb.

HEAVY CAP,
Weight : 97 lb.



DIN



STANDARD BASE,
Weight : 349 lb.

Rivets ⅞″ dia.

Scale ¾ inch = 1 foot.

BASE. This is designed to transmit loads up to 152 tons, the safe central load for a height of 12 feet, as given on page 87. Its effective area is sufficient, on reinforced concrete, for loads up to 106 tons (500 lb. per sq. inch) ; for greater loads, a grillage foundation is indicated.

CAPS. The shear value of the rivets in *each* flange cleat is, for the Heavy Cap 28·9 tons ; for the Light Cap 14·4 tons.

For further explanation, see page 112.

WELDED STANCHION CONNECTIONS

for

BROAD FLANGE BEAMS, GREY PROCESS.

WELDED STANCHION CONNECTIONS

FOR BROAD FLANGE BEAMS, GREY PROCESS.

The following notes relate to the *welded* designs of Caps, Bases, and Joints on pages 135 to 149. Details are given for the undermentioned sections of Broad Flange Beams in their DIE (minimum) and DIN (medium) weights respectively.

4″ × 4″ × 11·0 and 14·8 lb. per foot		Pages 135
6″ × 6″ × 17·6 ,, 24·9 ,, ,, ,, ...		136–137
7″ × 7″ × 24·8 ,, 34·7 ,, ,, ,, ...		138–139
8″ × 8″ × 30·1 ,, 43·6 ,, ,, ,, ...		140–141
8½″ × 8½″ × 34·5 ,, 48·0 ,, ,, ,, ...		142–143
10″ × 10″ × 44·2 ,, 61·1 ,, ,, ,, ...		144–145
11″ × 11″ × 51·4 ,, 75·7 ,, ,, ,, ...		146–147
12″ × 12″ × 58·9 ,, 81·2 ,, ,, ,, ...		148–149

WEIGHTS.

The stated weights allow for the fillet welds shown.

CAPS.

The cap plates are shown with the minimum projection (½″) required for the welding operation. Usually, no greater projection will be required, connection bolts to the supported girder(s) being located between the stanchion flanges; but the plates can be extended when necessary, *e.g.*, to provide a longer bearing for girders fishplated over the stanchion. The unstiffened plates are welded along the stanchion web and outside flange edges only.

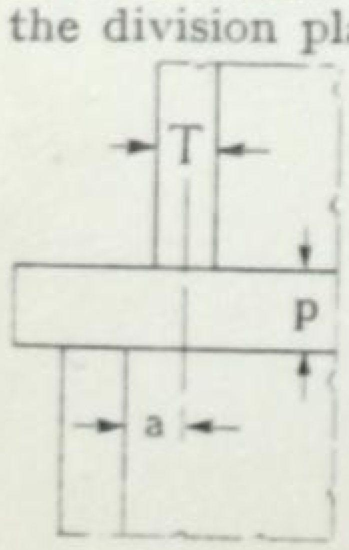
STANCHION JOINTS.

The type of joint shown for the various sections is more economical than the splice plates customary in riveted joints.

For the purposes of the drawings of DIN sections (right-hand pages), the upper stanchion is assumed to be the DIE (minimum) weight of the same section. In these and all other cases where the whole section of the upper stanchion has a direct bearing on the stanchion below, a sufficient thickness for the division plate is 3/8″ for sections up to 7″, 1/2″ for sections 8″ to 12″, and 5/8″ for sections 14″ to 18″.

In these DIN drawings, the sizes of the welds on the division plate have been made sufficient to yield not less than 50% of the moment of resistance of the lower stanchion.

In the drawings for DIE sections (left-hand pages), the upper stanchion is assumed to be a smaller DIE section (shown in the table below). In these cases, the thickness of the division plate has been made sufficient to transmit the load on the assumption that the upper stanchion is stressed to 4½ tons per sq. inch, allowing a flexural stress in the plate not exceeding 8 tons per square inch.



The required thickness (p) of the division plate will vary according to the length of the lever arm *a* in sketch and the load on the upper stanchion. Assuming the compressive stress in the upper stanchion flange to be 4½ tons per square inch, then the necessary thickness of the division plate, allowing a flexural stress in the plate not exceeding 8 tons per square inch, may be found by the formula

$$p = \sqrt{3 \cdot 375\ Ta}$$

WELDED STANCHION CONNECTIONS

FOR BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

The following are typical results of the application of this formula.

Lower Stanchion.	Upper Stanchion.	a (inches).	p (inches).
6″ Die	5″ Die	·375	5/8
7″ Die	5½″ Die	·575	7/8
8″ Die	6″ Die	·685	7/8
8½″ Die	7″ Die	·495	7/8
10″ Die	8″ Die	·655	1
11″ Die	9½″ Die	·465	7/8
12″ Die	10¼″ Die	·485	1
14″ Die	12½″ Die	·405	1
16″ Die	14″ Die	·365	1
18″ Die	16″ Die	·474	1-1/8

If the size of the upper stanchion is such that it has very nearly but not quite a complete direct bearing, an intermediate thickness for the bearing plate will be suitable.

For the sake of the fillet weld, the division plate must have a projection of not less than 1/2″, as shown on the drawings.

The web cleats provided serve only for bolting the stanchions together during erection; they are made *small*, usually only 3″ × 3″, so as to leave room for the welding between the cap plate and stanchion shaft. These angles are welded along the two vertical edges to the upper stanchion web, and along the outside edge to the division plate.*

SPLICE PLATES.

If the use of splice plates is preferred, as in Figs. 1 and 2 overleaf, the appropriate size of splice plates may be ascertained from the following table :—

Upper Stanchion.	Splice Plates.	Maximum Load.
4″ × 4″ Die	9″ × ⅜″	6·7 tons
6″ × 6″ Die	12″ × ⅜″	20 ,,
7″ × 7″ Die	,,	34 ,,
8″ × 8″ Die	12″ × ½″	46 ,,
8½″ × 8½″ Die	,,	56 ,,
10″ × 10″ Die	15″ × ½″	77 ,,
11″ × 11″ Die	18″ × ½″	94 ,,
12″ × 12″ Die	,,	110 ,,
14″ × 12″ Die	18″ × ⅝″	140 ,,
16″ × 12″ Die	,,	157 ,,
18″ × 12″ Die	22″ × ⅝″	178 ,,

* For sections 4″ to 10″, these web cleats are cut triangular in order to provide sufficient clearance (for the welding operation) between the cleat and the stanchion flanges.

WELDED STANCHION CONNECTIONS

FOR BROAD FLANGE BEAMS, GREY PROCESS.—Continued.

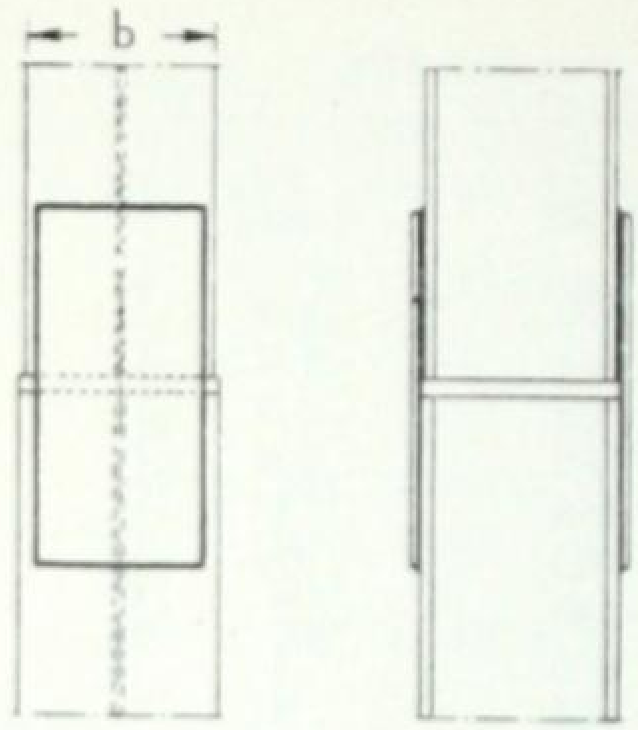


Fig. 1.
Stanchions of Die and Din weights respectively.

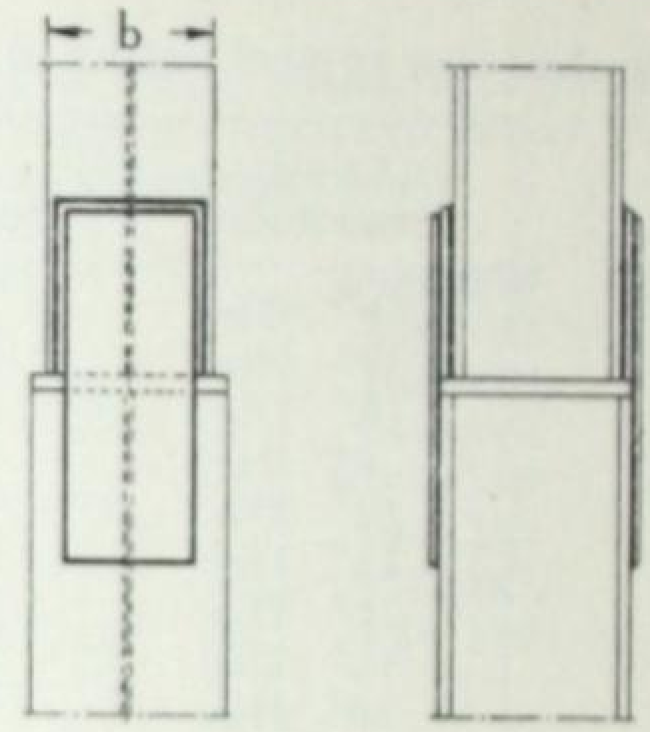


Fig. 2.
Stanchions of different section.

In Fig. 1, the width of the plates will be (b−1). The welds below the joint are $\frac{1}{4}''$ up to $12'' \times 12''$, and $\frac{3}{8}''$ for the $14''$ to $18''$ sections; above the joint, the presence of the thin filler plates necessitates a double run, and the welds are accordingly $\frac{3}{8}''$ for all sections.

In Fig. 2, the width of the plates will be (b − 2), and the welds will be $\frac{1}{4}''$ up to $12'' \times 12''$; $\frac{3}{8}''$ for the deeper sections.

These joints will be appropriate up to the specified " maximum load," this being the capacity of the stanchion by B.S.S. formula for a height of 12 feet, as tabulated on pages 84–87.

The welds shown in Figs. 1 and 2 are capable of transmitting not less than 50% of the load of the upper stanchion* when loaded to its capacity at 12 feet high; the remainder of the load being assumed to be transmitted by direct bearing.

BASES.

The bases shown are of approximately the same sizes as the riveted bases in the previous chapter, and are designed on the same general principles, as explained on page 113.

The fillet welds to gusset plates are assumed to be carried over the top in all cases, in order to make their full length effective.

VALUE OF WELDS.

The assumed values of the welds (see page 239), tons per lineal inch, are as follows :—

1/4″ fillet	... ...	·88 tons side,	1·24 tons end weld.
3/8″ „	... ...	1·33 „	„ 1·85 „ „ „
1/2″ „	... ...	1·77 „	„ 2·48 „ „ „

The assumed sectional areas and weights are :—

1/4″ fillet	... ...	·039 sq. ins.,	0·132 lb. per foot.
3/8″ „	... ...	·085 „	0·289 „ „ „
1/2″ „	... ...	1·31 „	0·446 „ „ „

For further explanation, see subsequent chapter on " Welding," pages 233—248.

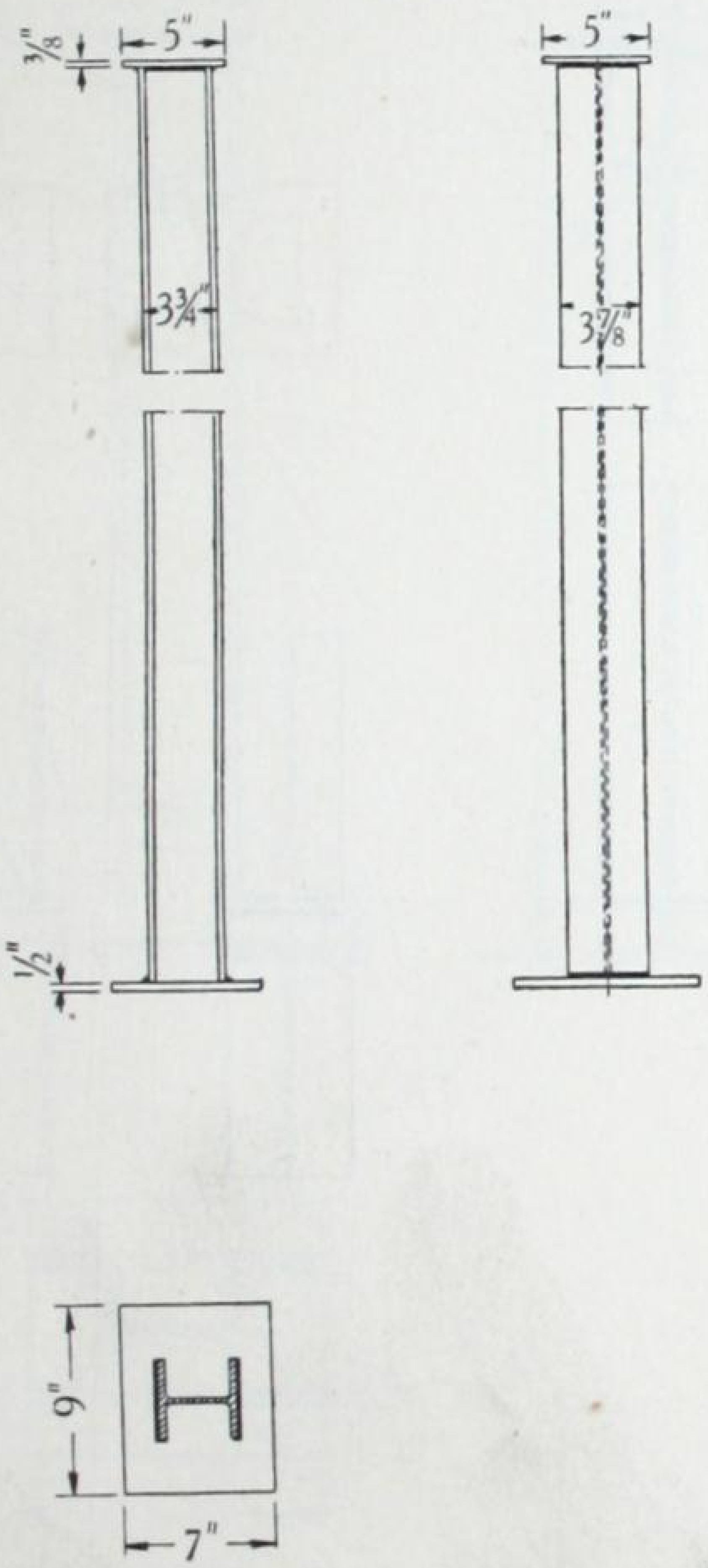
* Considerably *more* than 50% for the smaller sections.

WELDED STANCHION DETAILS FOR

B.F. BEAM 4″ × 4″ × 11 to 15 lb., GREY PROCESS.

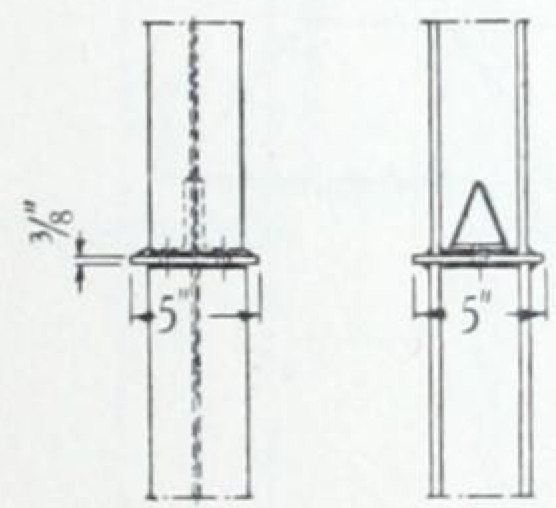
For Riveted Alternatives, see page 114.

Weight of Cap, 3 lb.



DIE or DIN

In the following pages, separate designs are given for Die and Din weights of each section; in this instance, the details shown are equally appropriate for both weights.



Weight of Base, 9 lb.

1/4″ Fillet Welds throughout.

Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ⅜″, will vary according to the section and load of the upper stanchion; see page 133.

The stanchion base is designed to transmit loads up to 9·7 tons, the safe central load of the Din weight (15 lb. per foot) for a height of 12 feet, as given on page 85. Its area, 0·44 sq. feet, is sufficient for any good concrete foundation, with or without reinforcement.

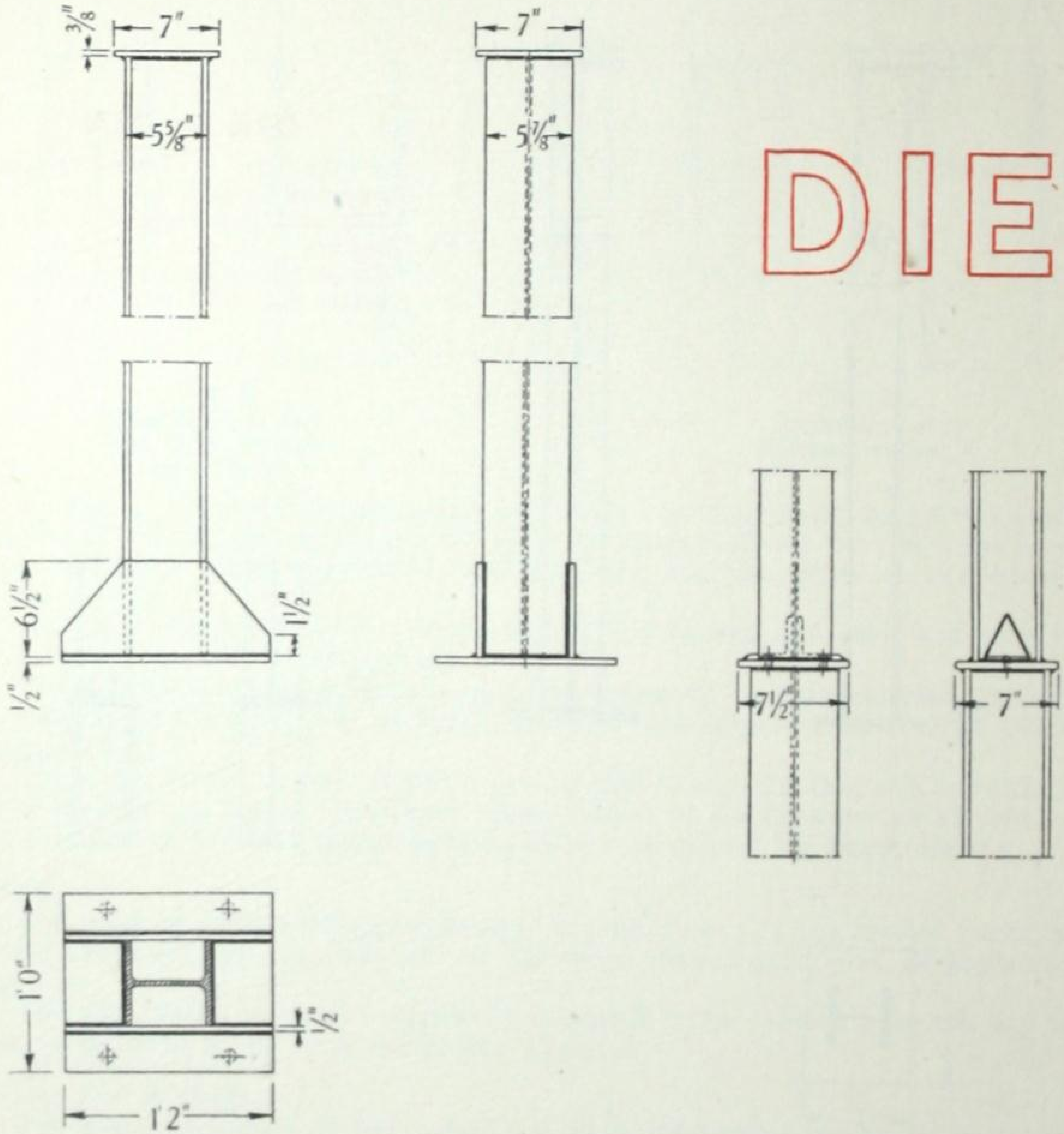
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 6″ × 6″ × 18 lb., GREY PROCESS.

For Riveted Alternatives, see page 116.

Weight of Cap, 5½ lb.



Weight of Base, 45 lb.

1/4″ Fillet Welds throughout.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ½″, will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 20 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·17 sq. feet, is sufficient for any good concrete foundation, with or without reinforcement.

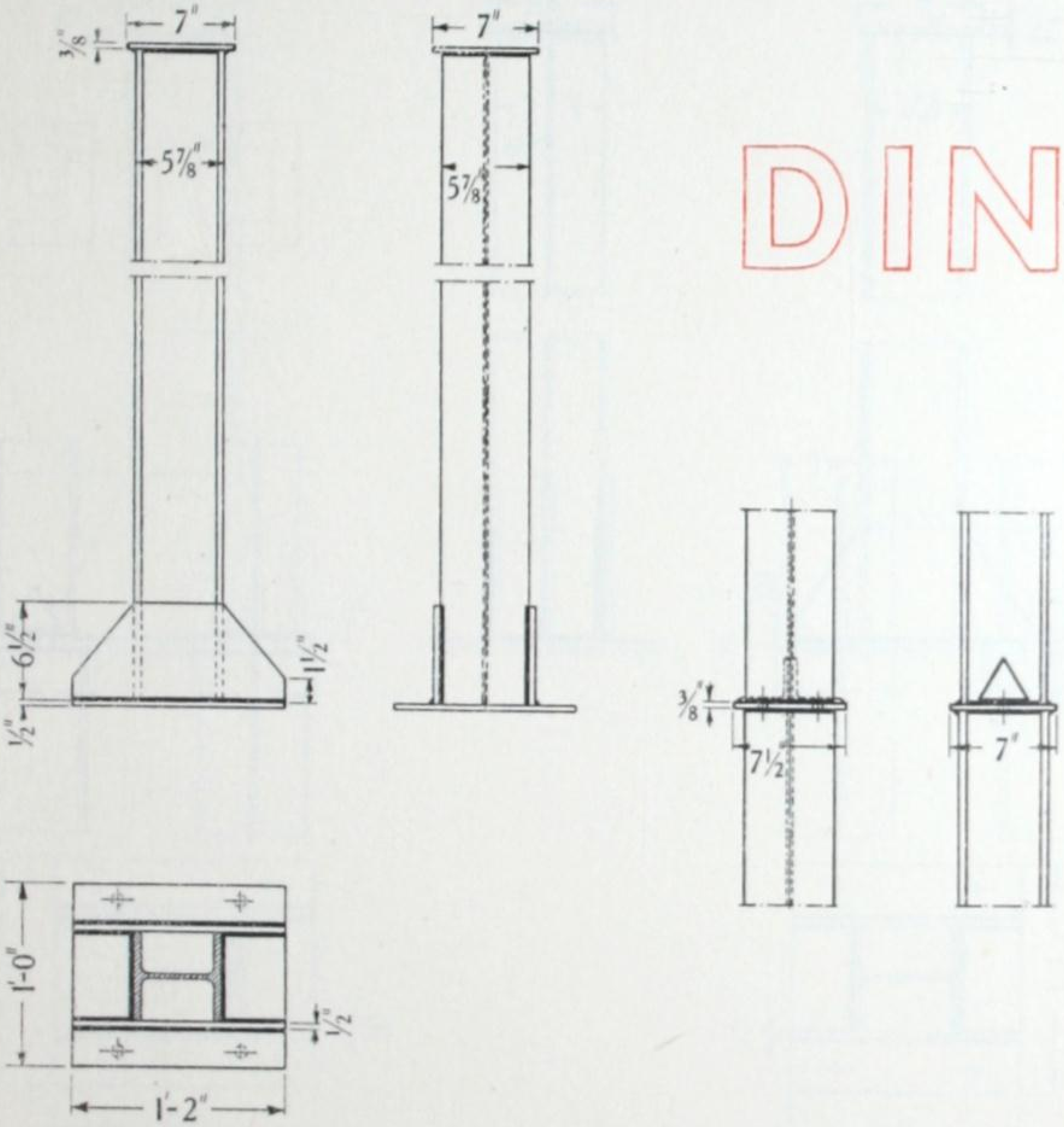
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 6″ × 6″ × 25 lb., GREY PROCESS.

For Riveted Alternative, see page 117.

Weight of Cap, 5½ lb.



Weight of Base, 45 lb.

1/4″ Fillet Welds throughout.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ⅜″, will vary according to the section and load of the upper stanchion ; see page 133.

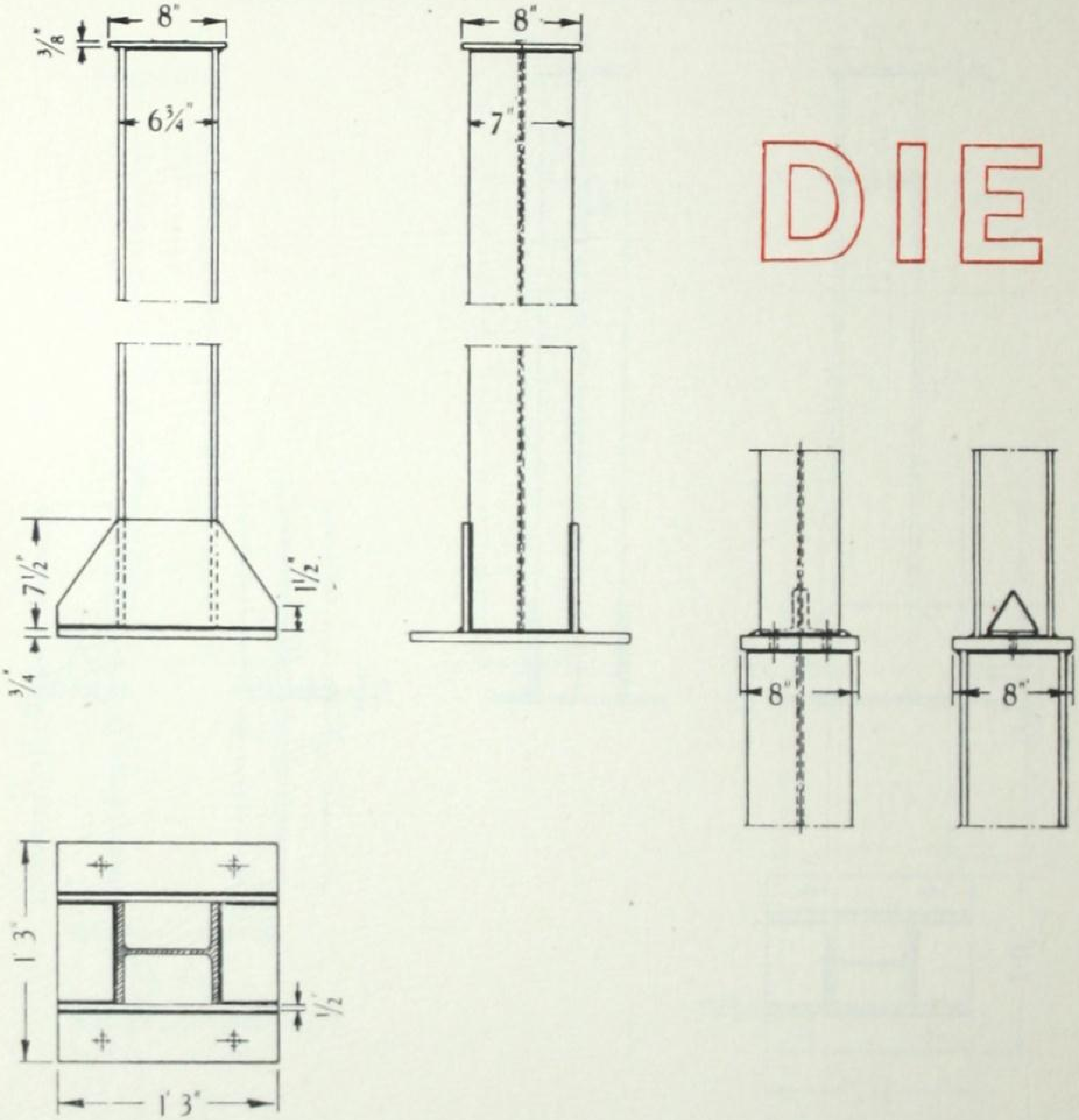
The stanchion base is designed to transmit loads up to 29 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·17 sq. feet, is sufficient for any good concrete foundation, with or without reinforcement.

For further explanation of these drawings, see pages 132–134

WELDED STANCHION DETAILS FOR
B.F. BEAM 7″ × 7″ × 25 lb., GREY PROCESS.

For Riveted Alternatives, see page 118.

Weight of Cap, 7 lb.



Weight of Base, 74 lb.

1/4″ Fillet Welds throughout.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ⅞″, will vary according to the section and load of the upper stanchion ; see page 133.

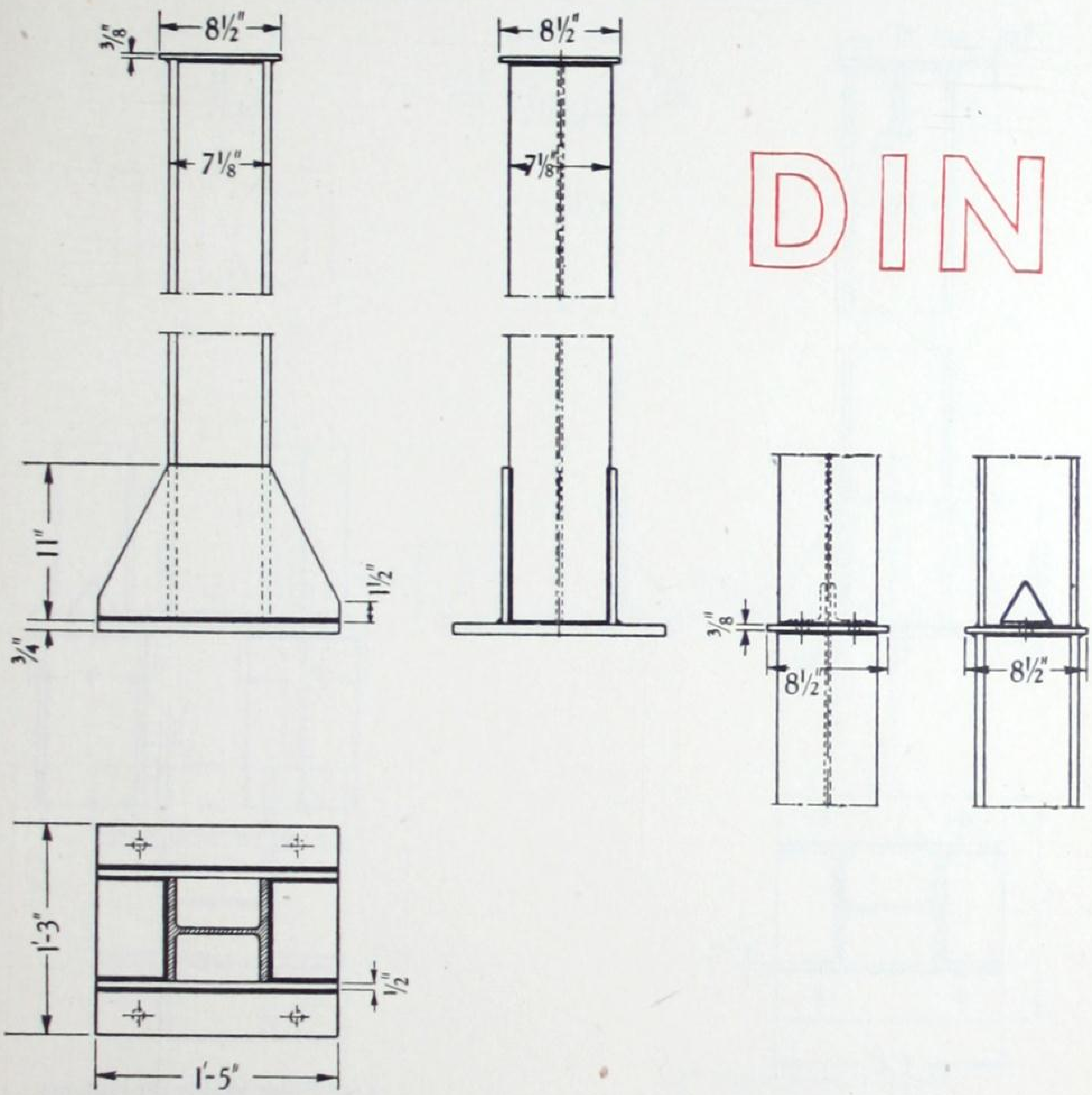
The stanchion base is designed to transmit loads up to 34 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·56 sq. feet, is sufficient for a reinforced concrete foundation.

For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR
B.F. BEAM 7″ × 7″ × 35 lb., GREY PROCESS

For Riveted Alternative, see page 119.

Weight of Cap, 8 lb.



Weight of Base, 95 lb.

1/4″ Fillet Welds (in black) throughout.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ⅜″, will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 50 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·77 sq. feet, is sufficient for a reinforced concrete foundation.

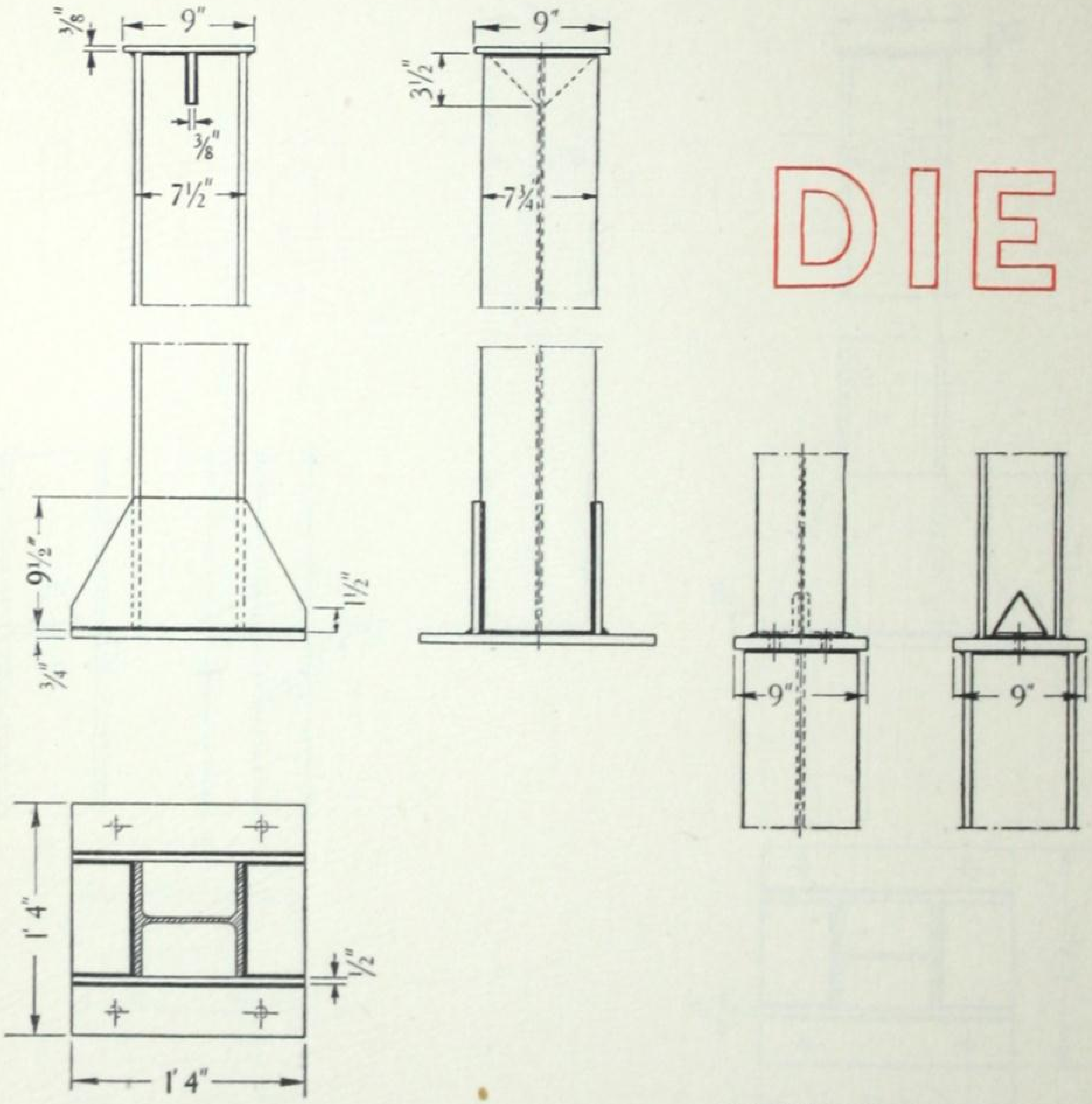
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 8″ × 8″ × 30 lb., GREY PROCESS.

For Riveted Alternatives, see page 120.

Weight of Cap, 10½ lb.



Weight of Base, 89 lb.

1/4″ Fillet Welds throughout.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ⅞″, will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 46 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 1·78 sq. feet, is sufficient for a reinforced concrete foundation.

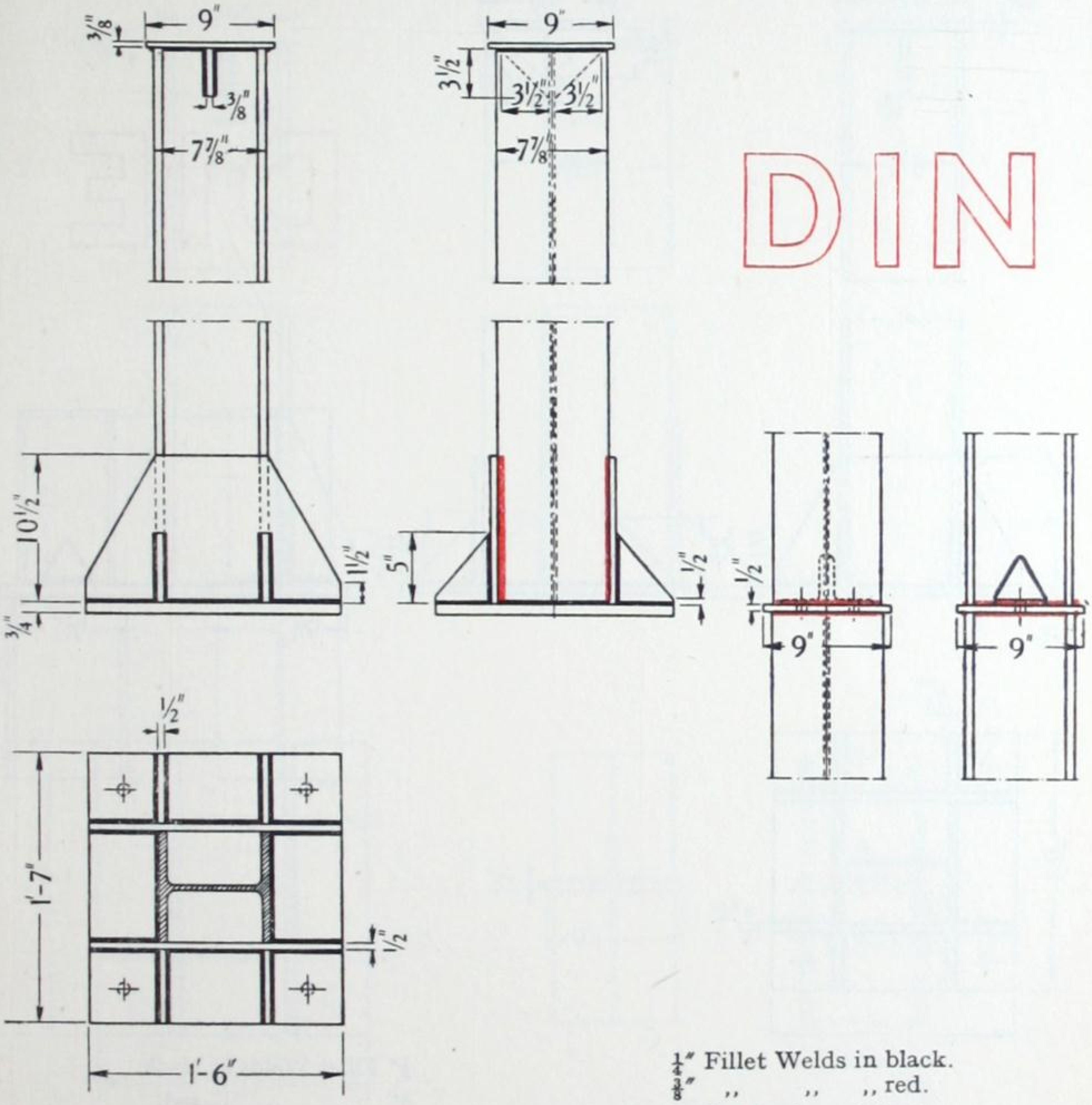
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 8″ × 8″ × 44 lb., GREY PROCESS.

For Riveted Alternative, see page 121.

Weight of Cap, $10\frac{1}{2}$ lb.



Weight of Base, 124 lb.

$\frac{1}{4}$″ Fillet Welds in black.
$\frac{3}{8}$″ ,, ,, ,, red.
Scale $\frac{3}{4}$ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as $\frac{1}{2}$″, will vary according to the section and load of the upper stanchion ; see page 133.

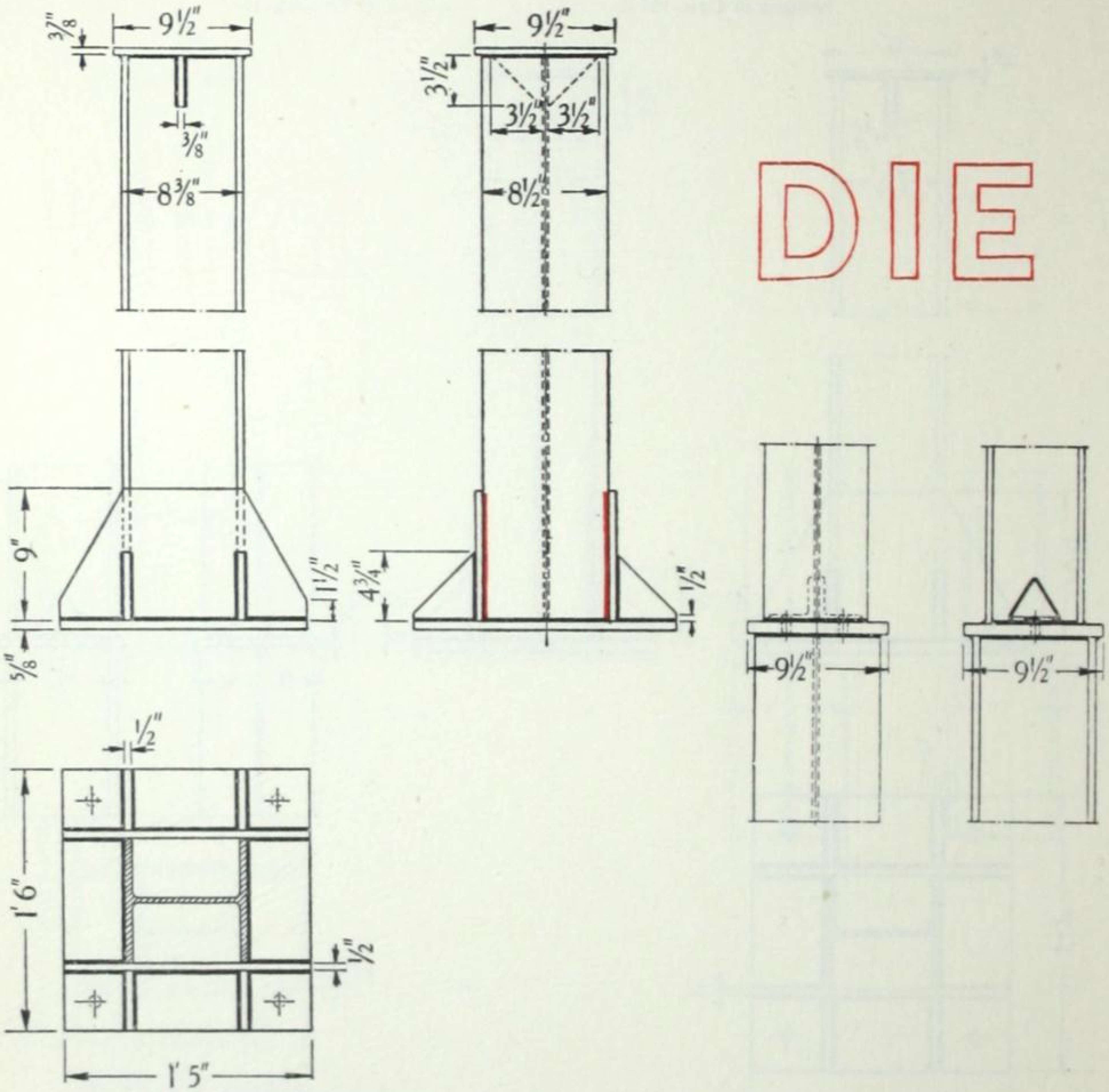
The stanchion base is designed to transmit loads up to 68 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 2·38 sq. feet, is sufficient for a reinforced concrete foundation.

For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR
B.F. BEAM $8\frac{1}{2}'' \times 8\frac{1}{2}'' \times 34\frac{1}{2}$ lb., GREY PROCESS.

For Riveted Alternative, see page 122.

Weight of Cap, $11\frac{1}{2}$ lb.



$\frac{1}{4}''$ Fillet Welds in black.
$\frac{3}{8}''$,, ,, ,, red.
Scale $\frac{3}{4}$ inch = 1 foot.

Weight of Base, 97 lb.

The required thickness of the division plate in the stanchion joint, here shown as $\frac{7}{8}''$, will vary according to the section and load of the upper stanchion; see page 133.

The stanchion base is designed to transmit loads up to 56 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 2·12 sq. feet, is sufficient for a reinforced concrete foundation.

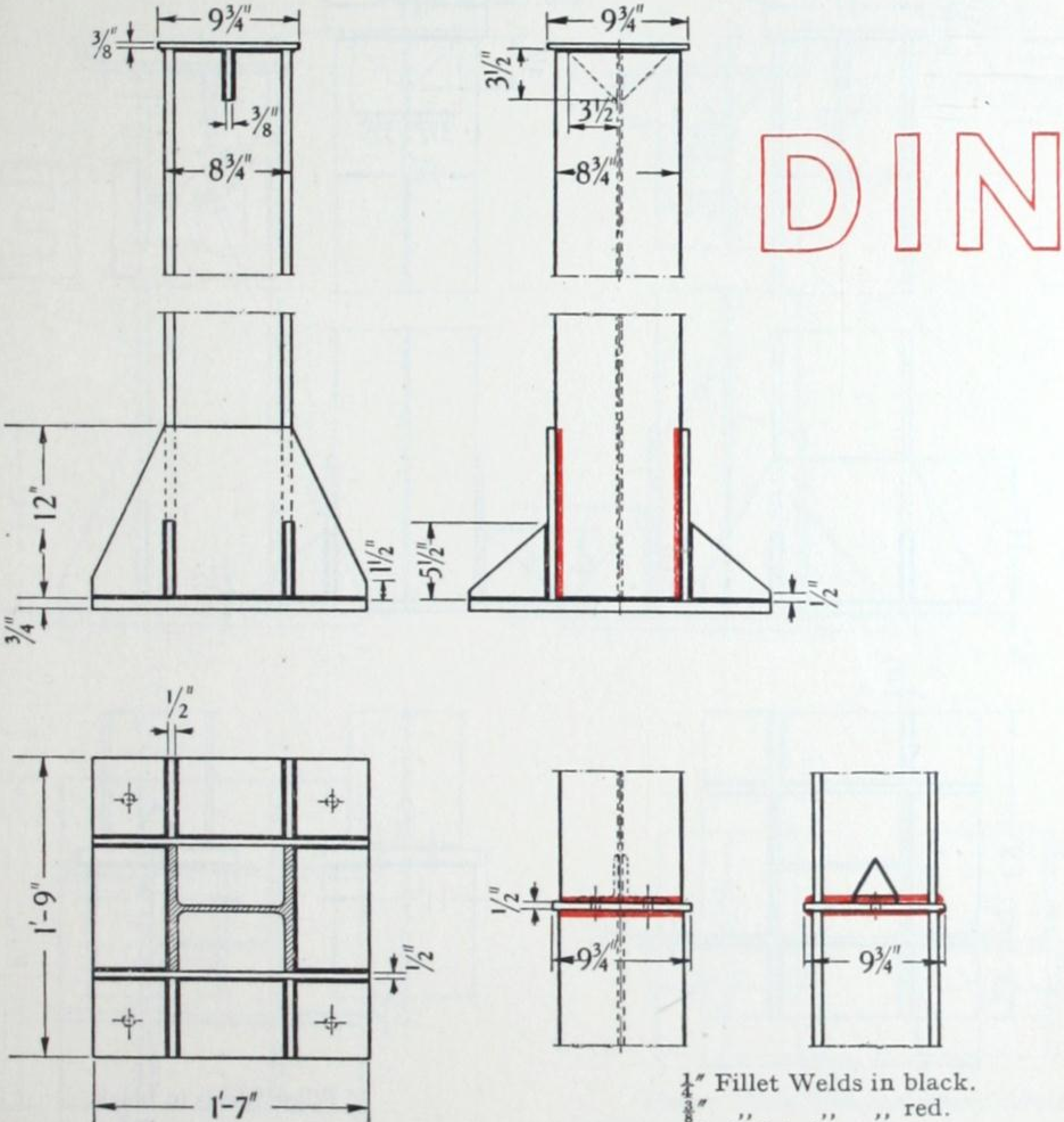
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM $8\frac{1}{2}'' \times 8\frac{1}{2}'' \times 48$ lb., GREY PROCESS.

For Riveted Alternative, see page 123.

Weight of Cap, 12 lb.



Weight of Base, 146 lb.

$\frac{1}{4}''$ Fillet Welds in black.
$\frac{3}{8}''$,, ,, ,, red.
Scale $\frac{3}{4}$ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as $\frac{1}{2}''$, will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 79 tons, the safe central load for a height of 12 feet, as given on page 85. Its area, 2·77 sq. feet, is sufficient for a reinforced concrete foundation.

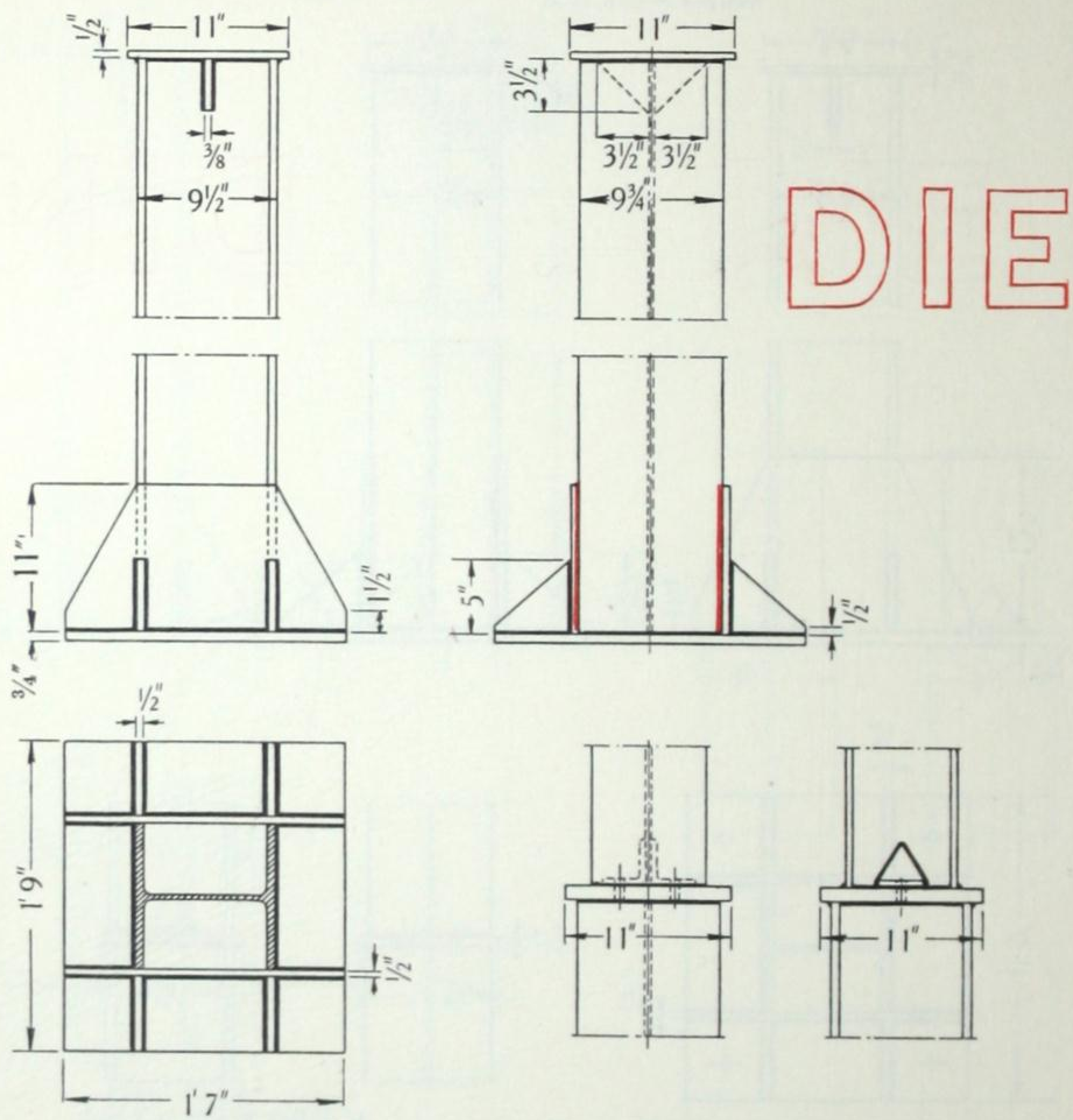
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 10″ × 10″ × 44 lb., GREY PROCESS.

For Riveted Alternatives, see page 124 For Slab bases, see page 15

Weight of Cap, 19 lb.



Weight of Base, 141 lb.

¼″ Fillet Welds in black.
⅜″ ,, ,, ,, red.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as 1″, will vary according to the section and load of the upper stanchion; see page 133.

The stanchion base is designed to transmit loads up to 77 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 2·77 sq. feet, is sufficient for a reinforced concrete foundation.

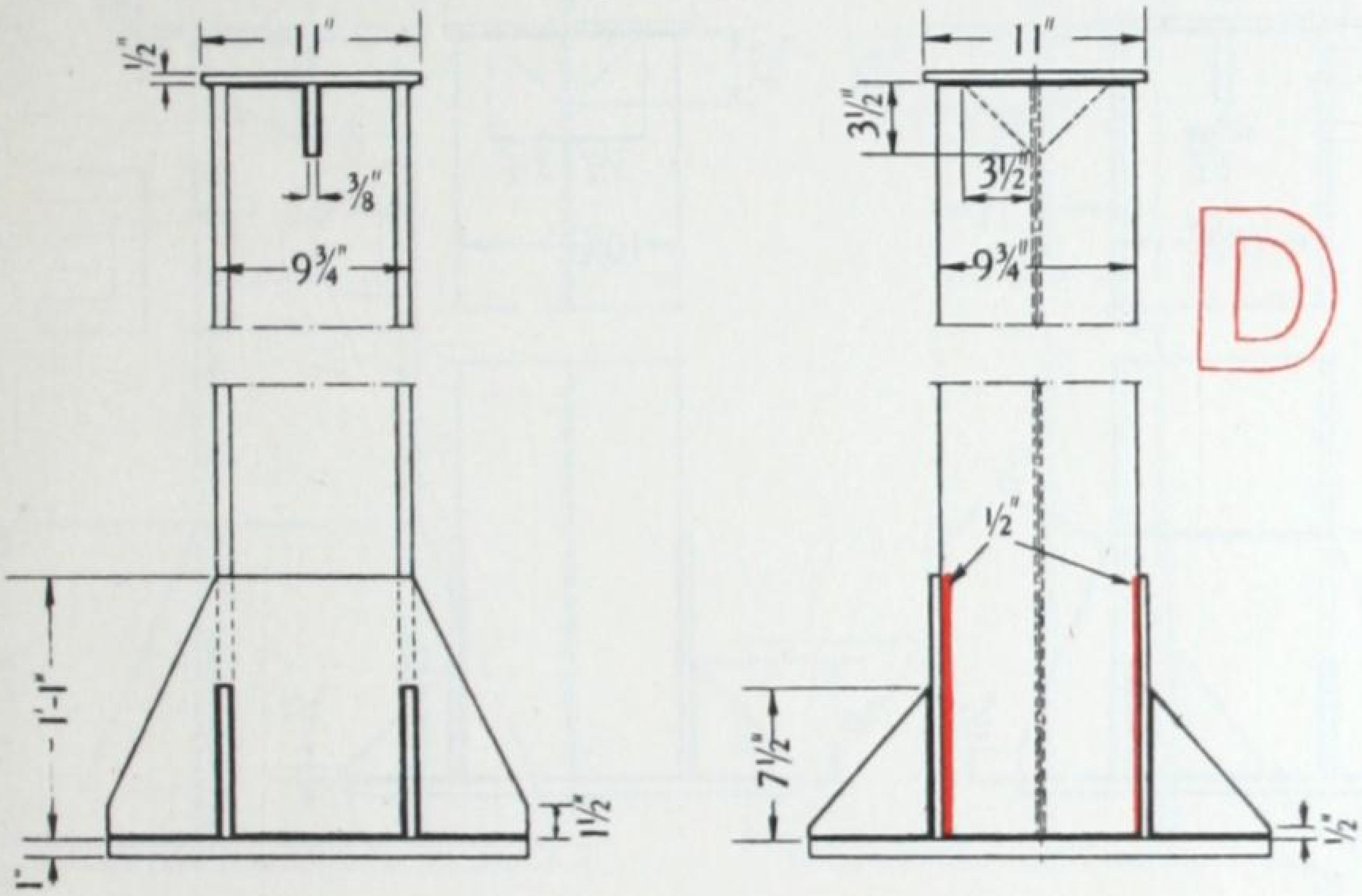
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 10″ × 10″ × 61 lb., GREY PROCESS.

For Riveted Alternative, see page 25. For Slab bases, see page 151.

Weight of Cap, 19 lb.



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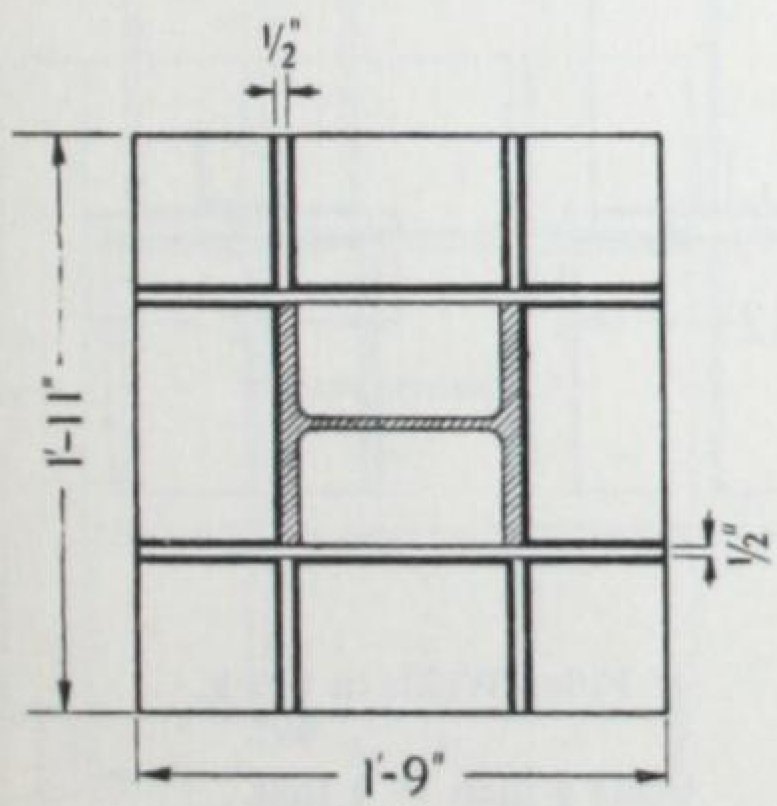
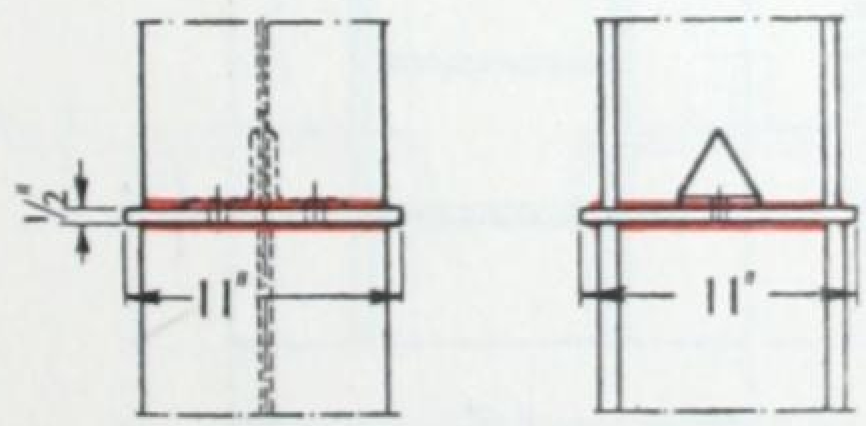


Weight of Base, 214 lb.



Heavy black lines indicate ¼″ fillets.
Red lines are ⅜″ fillets except where marked ½″.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ½″, will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 108 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 3·35 sq. feet, is sufficient for a reinforced concrete foundation.

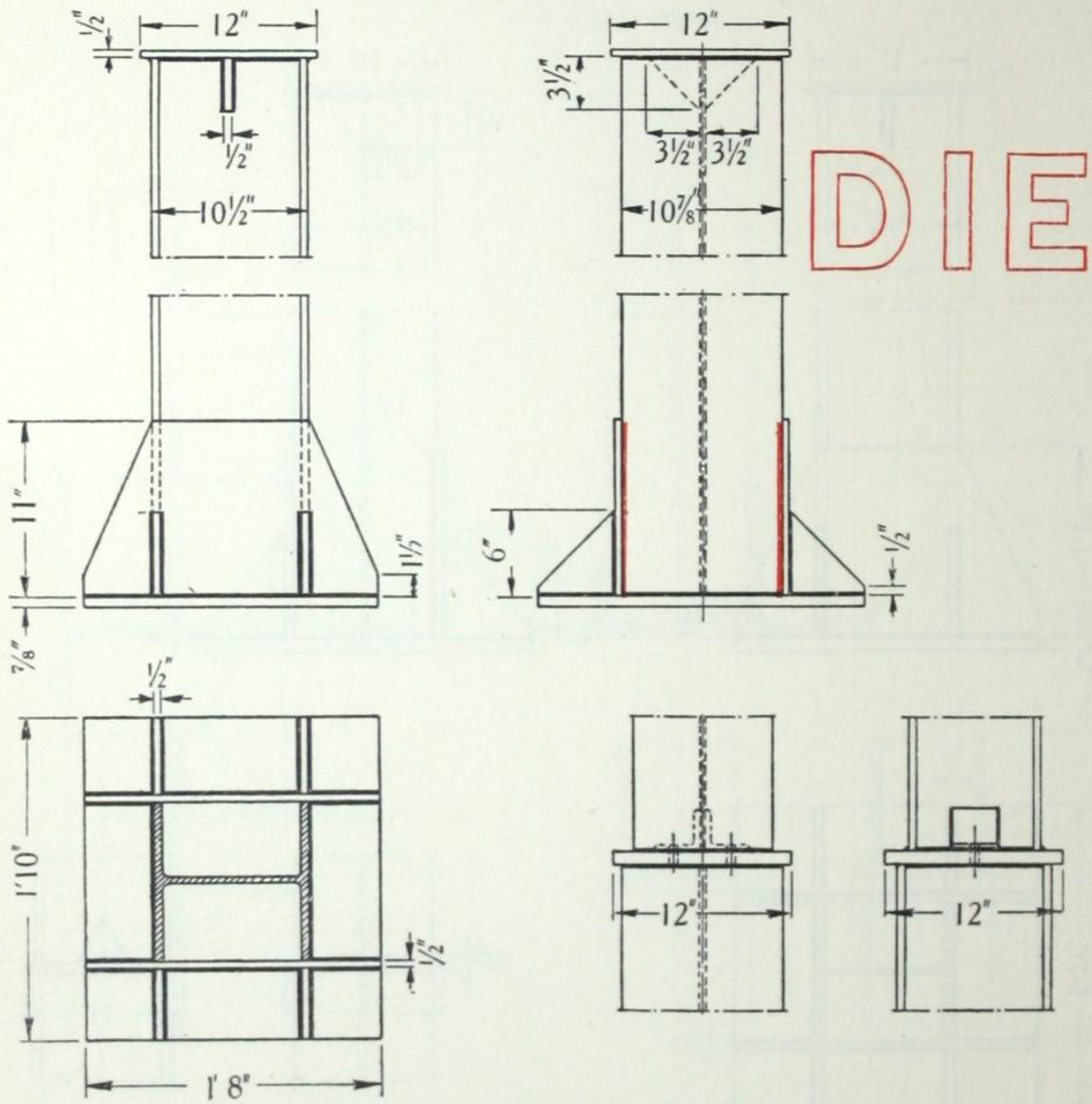
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 11″ × 11″ × 51½ lb., GREY PROCESS.

For Riveted Alternative, see page 126.   For Slab bases, see page 151.

Weight of Cap, 23 lb.



Weight of Base, 171 lb.

¼″ Fillet Welds in black.
½″ ,, ,, ,, red.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ⅞″, will vary according to the section and load of the upper stanchion; see page 133.

The stanchion base is designed to transmit loads up to 94 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 3·06 sq. feet, is sufficient for a reinforced concrete foundation.

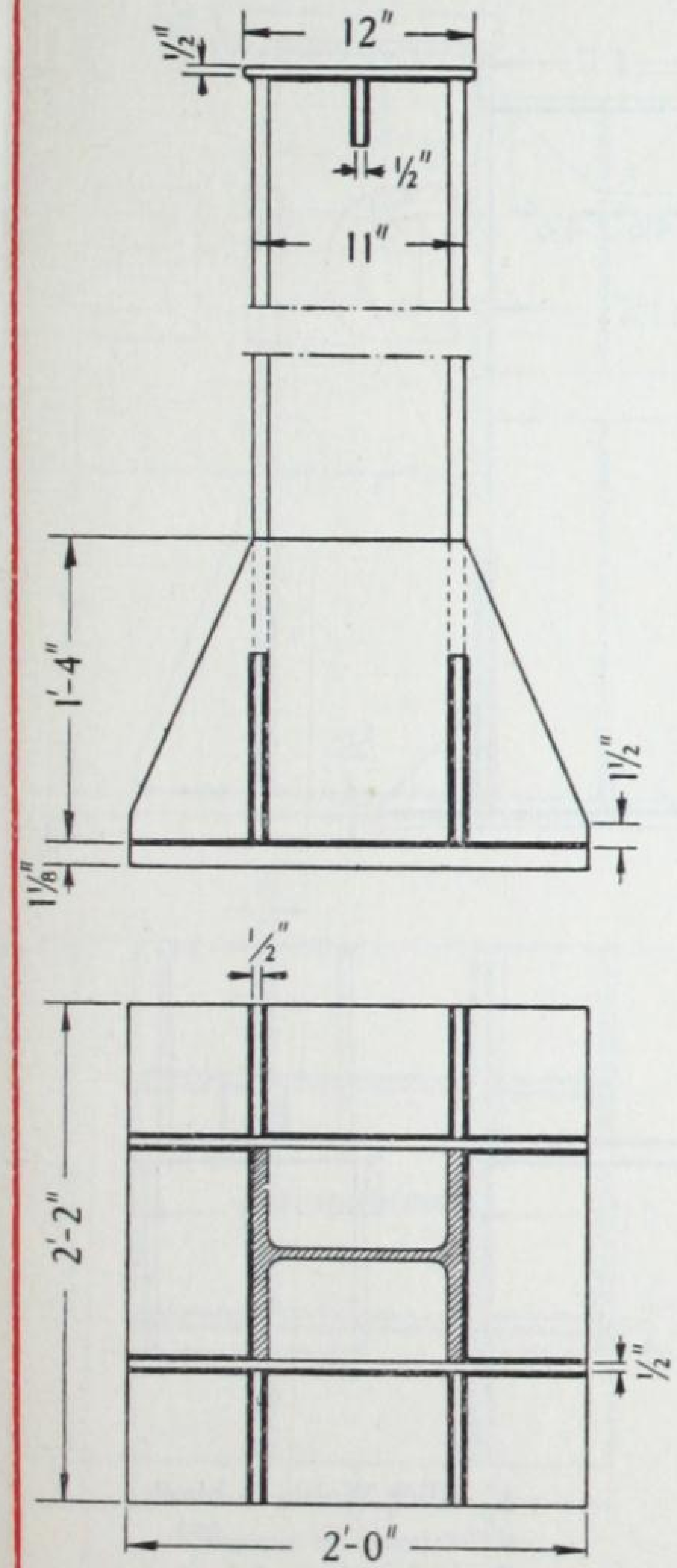
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

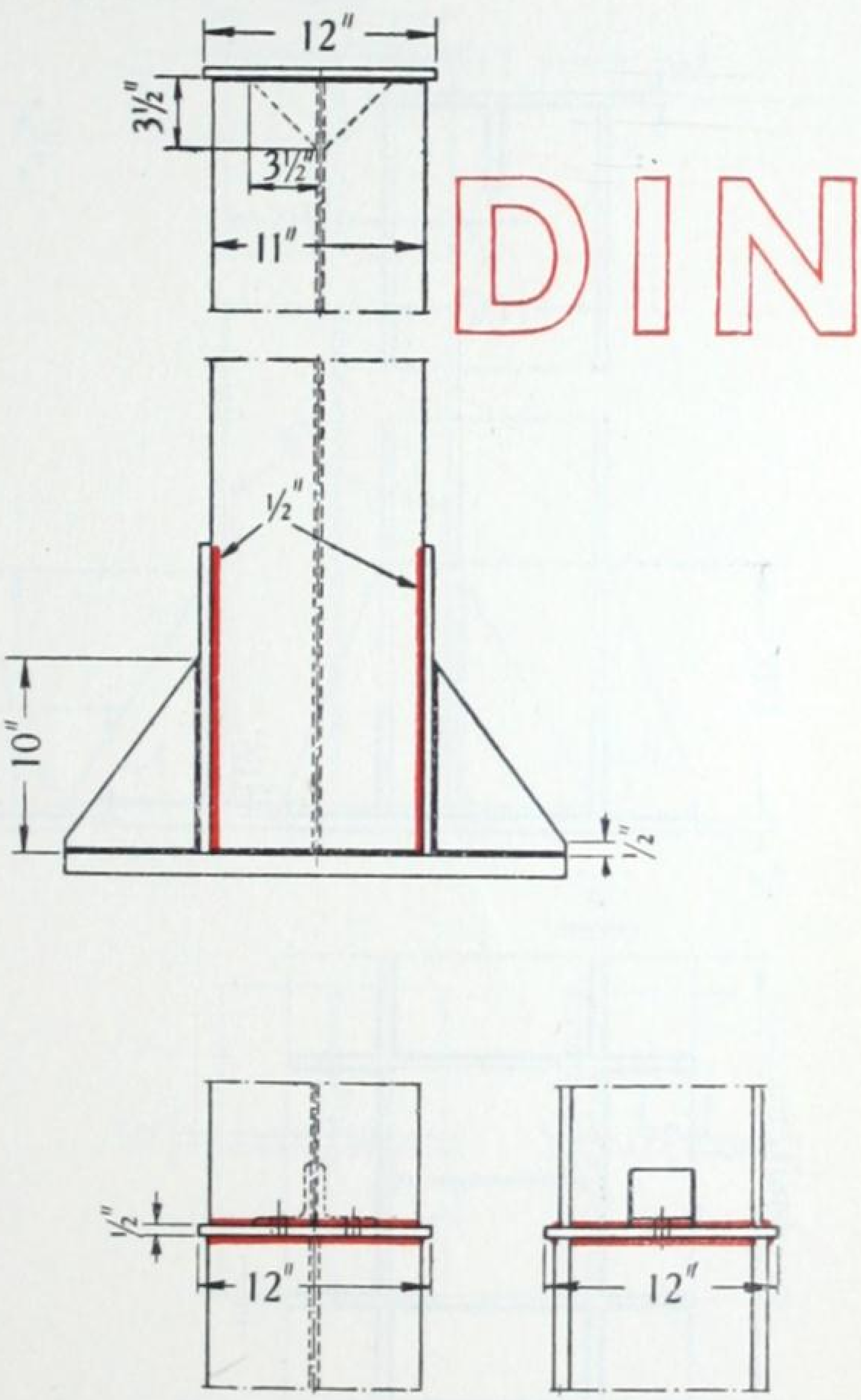
B.F. BEAM 11″ × 11″ × 76 lb., GREY PROCESS.

For Riveted Alternative, see page 127. For Slab bases, see page 151.

Weight of Cap, 23lb.



Weight of Base, 307lb.



Heavy black lines indicate ¼″ fillets.
Red lines are ⅜″ fillets except where marked ½″.
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ½″, will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 139 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 4·33 sq. feet, is sufficient for a reinforced concrete foundation.

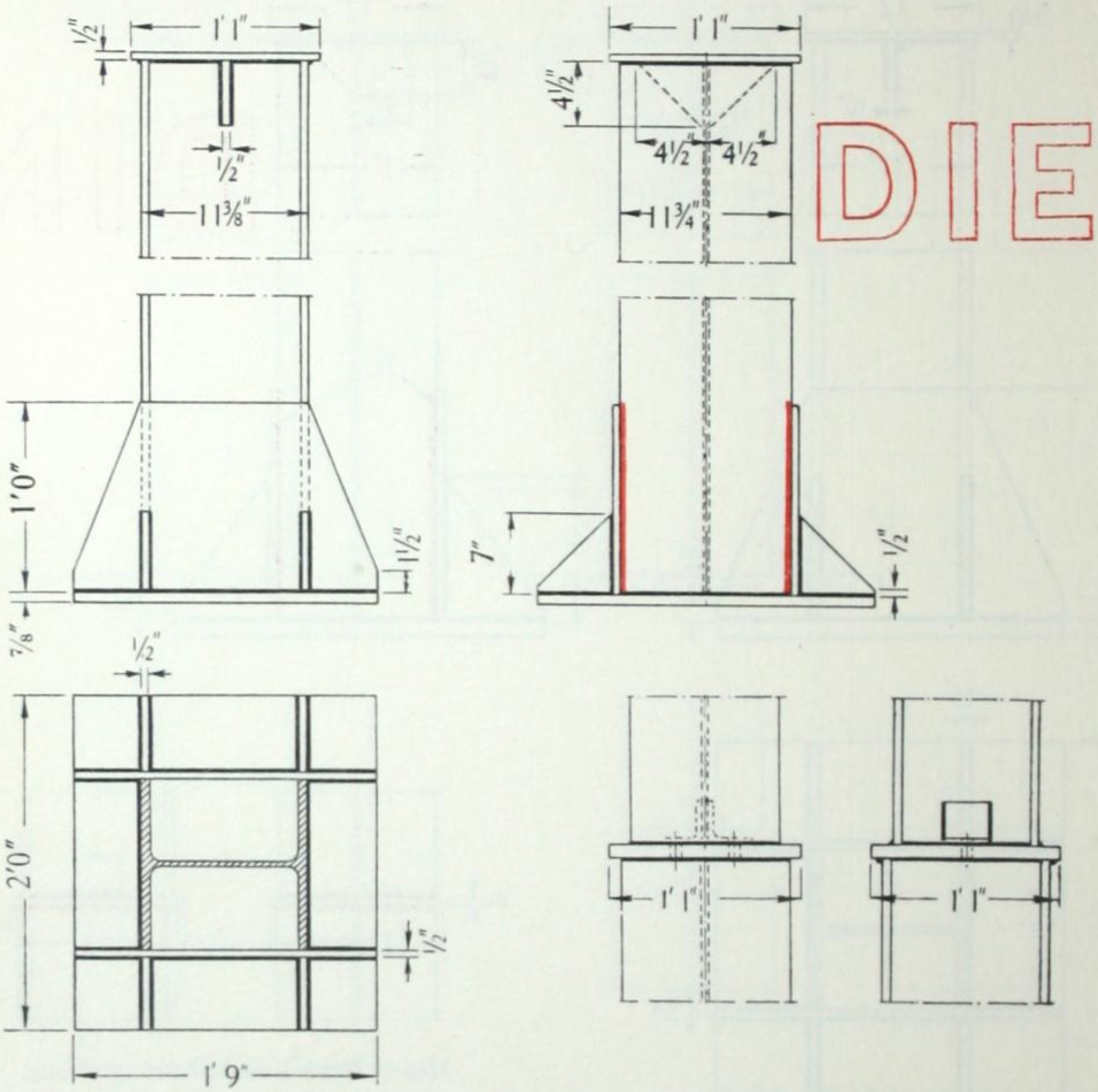
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR

B.F. BEAM 12″ × 12″ × 59 lb., GREY PROCESS.

For Riveted Alternative, see page 128. For Slab bases, see page 151.

Weight of Cap, 28 lb.



Weight of Base, 198 lb.

¼″ Fillet Welds in black.
½″ ,, ,, ,, red.
Scale ¼ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as 1″, will vary according to the section and load of the upper stanchion; see page 133.

The stanchion base is designed to transmit loads up to 110 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 3·5 sq. feet, is sufficient for a reinforced concrete foundation.

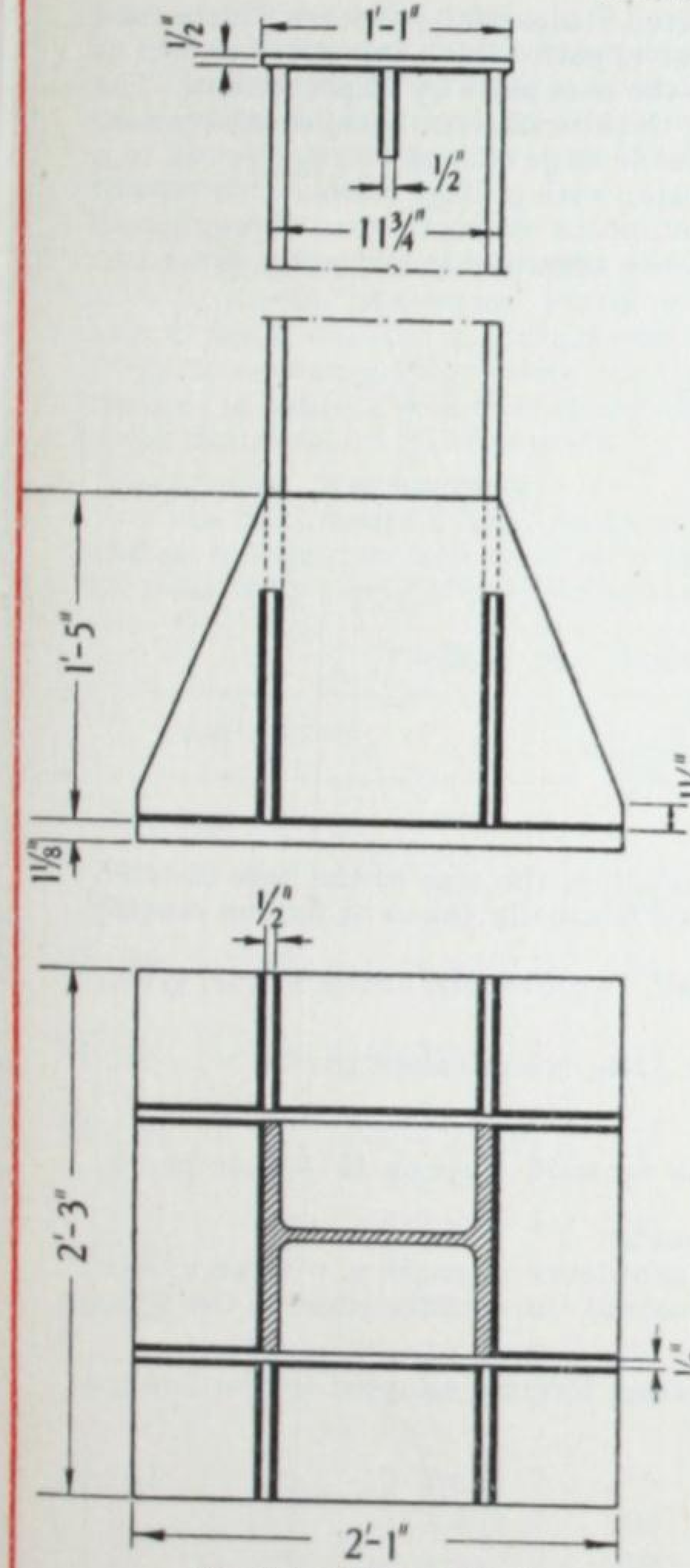
For further explanation of these drawings, see pages 132–134.

WELDED STANCHION DETAILS FOR
B.F. BEAM 12" × 12" × 81 lb., GREY PROCESS.

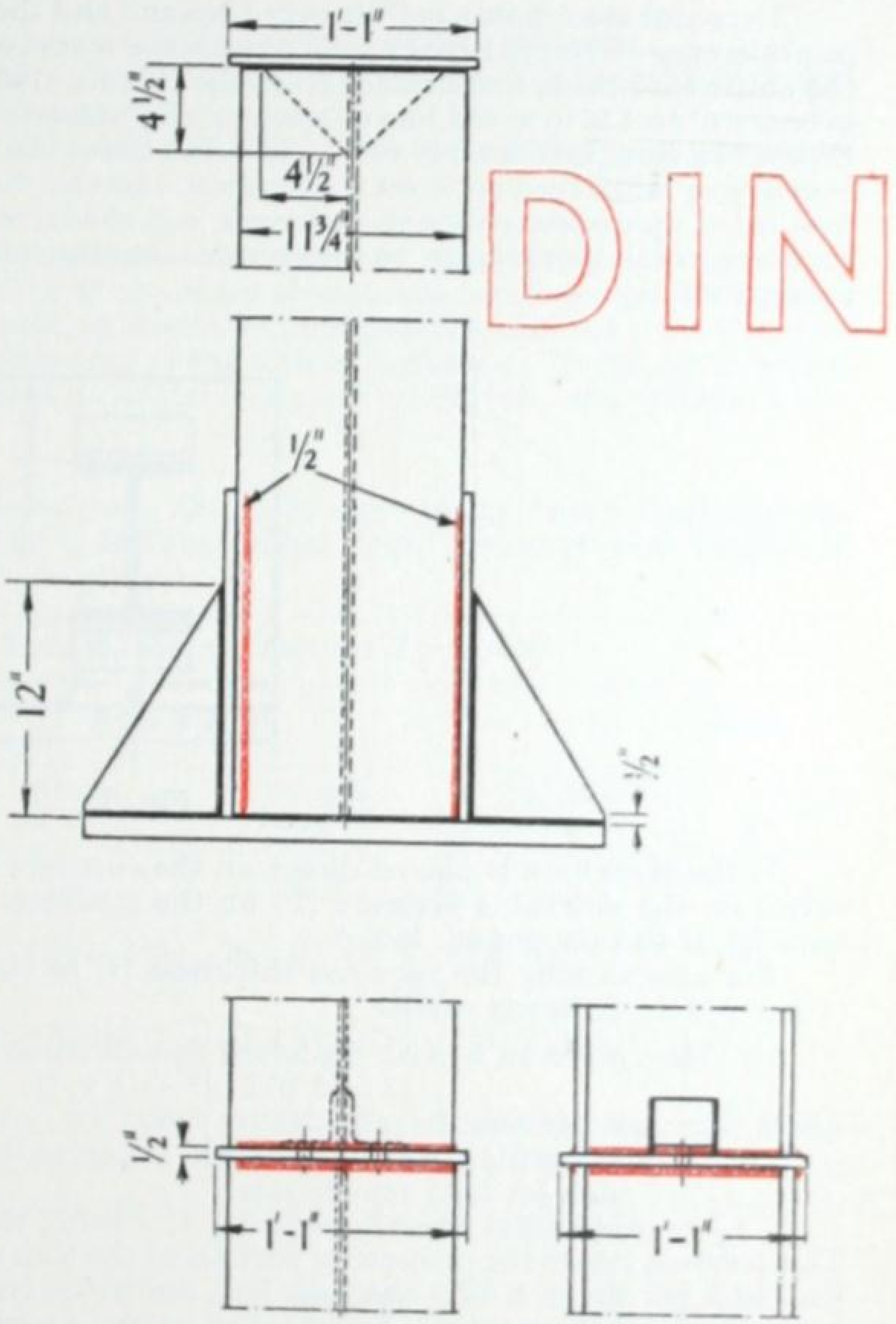
For Riveted Alternative, see page 129.

For Slab bases, see page 151.

Weight of Cap, 28lb.



Weight of Base, 337 lb.



Heavy black lines indicate ¼" fillets.
Red lines are ⅜" fillets except where marked ½".
Scale ¾ inch = 1 foot.

The required thickness of the division plate in the stanchion joint, here shown as ½", will vary according to the section and load of the upper stanchion ; see page 133.

The stanchion base is designed to transmit loads up to 152 tons, the safe central load for a height of 12 feet, as given on page 87. Its area, 4·69 sq. feet, is sufficient for a reinforced concrete foundation.

For further explanation of these drawings, see pages 132–134.

Poles, Piles.
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Rivets, Bolts.
Roofs, Concrete
Welding
Plates, Inertia.
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

SLAB BASES FOR STANCHIONS.

In recent steel-frame buildings in England and the United States, slab bases are widely used in preference to riveted bases ; slab bases are made with steel plates thick enough to permit of the entire load being transmitted from the column shaft to the base plate by direct contact. The primary object is to avoid loss of space in the basement, or the alternative of deeper excavation. Unless the stanchion load is very great, slab bases can be made large enough to go direct on to a concrete or reinforced concrete foundation, thereby dispensing with grillage joists. This type of base is not appropriate for exposed work, e.g. sheds, tank supports, viaducts, etc., where there is an overturning moment to be taken into account, unless the structure is efficiently braced to prevent raking.

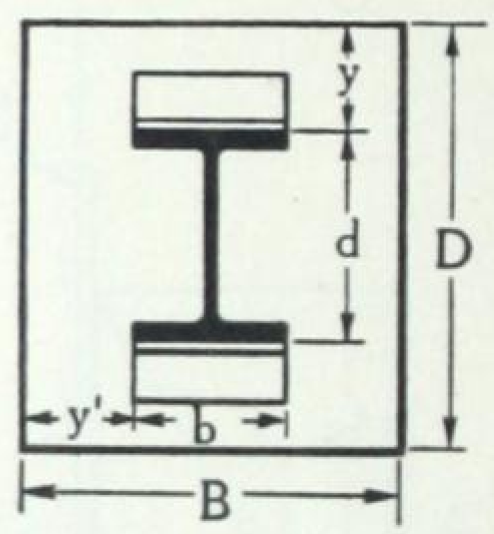

Fig. 1.

If the stanchion is placed direct on the concrete foundation, the area of the base is determined by the allowable pressure (P) on the concrete. This is usually taken at figures ranging from 30 to 40 tons per sq. foot.*

For ascertaining the required thickness (t) of the slab, two formulæ are in vogue, giving rather widely different results.

(i) That given in British Standard Specification **449**, §25a, is equivalent to :—

$$t^2 = 3\ p/f\ (y^2 - \tfrac{1}{4}\ y_1{}^2).$$

where p = safe pressure in tons per sq. inch,
f = safe tensile stress in the steel, taken as 9 tons for mild steel or 13·5 tons per sq. inch for high tensile steel.
y, y_1 = projections of slab, as in fig. 1, y being the greater.

This formula treats the projecting portion of the slab as a cantilever of length y, with an upward load of p per sq. inch over the area B y, and takes into account the counter-effect of the transverse strain, Poisson's ratio being taken as one-fourth.

(ii) The more conservative and theoretically less correct formula adopted in the London County Council's By-laws, 1937 (§69) is equivalent to :—

$$t^2 = \frac{3W}{4\ f}\left(\frac{D - d}{B}\right)$$

where (D — d) is the greater overhang,†
W = total axial load in tons,
f = safe tensile stress, taken as 9 tons per sq. inch, as before.

This formula assumes the maximum bending moment to be at the centre of the slab, treating it in effect as a pair of cantilevers of span B/2 with an upward load W/2 distributed over B/2 and an equal downward load distributed over b/2.

In the table on page 151, appropriate dimensions of mild steel bases are given for both formulæ, and for alternative bearing pressures of 40, 35 and 35, 30 tons per sq. foot.

* In a case cited by Mr. Bylander of a London building erected in 1910, a pressure of 1,000-lb. (64 tons per sq. foot) was used safely ; but this is considered too low a margin.

† Sometimes (B — b) will exceed (D — d), in which case for $\frac{D - d}{b}$ substitute $\frac{B - b.}{d}$

SLAB BASES—Continued.

SLAB BASES ON GRILLAGES.

The thicknesses of slab bases on grillages are calculated in a similar manner.

The breadth of the plate is determined by the size and number of R.S.J.'s beneath, sufficient space being left between the flanges for concreting in.

The depth of the plate is arranged so that the overhang is not so great as to necessitate an uneconomical base.

MACHINING.

In American practice, slabs up to 2" thick are rolled flat and smooth enough to be used without further treatment. Plates over 2" to 4" thick are straightened in a press; with plates over 4" thick, the area in contact with the column shaft and its angles is machined; if a slab over 4" thick rests on grillage joists, the underside also of the slab is machined. In British practice, the area in contact with the column shaft and its angles is usually machined; the underside also if the slab rests on grillage joists.

COMMERCIAL THICKNESSES.

The thicknesses of slab bases as ordered from the mills are usually round figures to the nearest fourth of an inch up to $1\frac{1}{2}''$; over $1\frac{1}{2}''$, to the nearest half-inch. About $\frac{1}{8}''$ must be allowed for machining; or $\frac{1}{4}''$ if both surfaces are to be planed.

TABLE A. Sizes of Slab Bases by Various Formulæ.

Size of Column.			Assumed Load (W).	B.S.S. Formula.		L.C.C. Formula.	
Nominal.		Actual.		40 Tons per sq. ft.	35 Tons per sq. ft.	35 Tons per sq. ft.	30 Tons per sq. ft.
Ins.	Lb.	Ins. d × b	Tons.	Ins.	Ins.	Ins.	Ins.
10×10	103	10·8×10·1	184	26×26×2·1	28×27×2·1	28×27×3·1	30×30×3·2
11×11	135	12·2×11·4	250	30×30×2·5	33×32×2·5	33×32×3·7	35×35×3·8
12×12	59	11·4×11·7	110	20×20×1·1	21×22×1·3	21×22×2·1	23×23×2·2
,,	81	11·8×11·8	152	24×23×1·6	25×25×1·6	25×25×2·6	27×27×2·7
,,	158	13·2×12·2	298	34×32×2·8	36×34×2·9	36×34×4·1	39×37×4·2
14×12	76	13·7×11·7	140	24×21×1·4	25×23×1·4	25×23×2·4	27×25×2·5
,,	101	14·2×11·8	188	27×25×1·8	29×27×1·9	29×27×2·9	32×29×3·1
,,	170	15·4×12·2	320	36×32×2·8	38×35×2·8	38×35×4·1	41×38×4·2
16×12	85	15·3×11·7	157	26×22×1·4	27×24×1·4	27×24×2·5	29×26×2·6
,,	110	15·7×11·8	205	30×25×1·9	31×28×2·0	31×28×3·1	33×30×3·1
,,	172	16·9×12·1	323	37×32×2·6	39×34×2·7	39×34×4·2	42×37×4·3
18×12	96	17·2×11·7	178	28×23×1·5	30×25×1·6	30×25×2·8	32×27×2·9
,,	122	17·7×11·8	227	32×26×1·9	34×28×2·0	34×28×3·3	36×31×3·3
,,	175	18·7×12·0	327	38×31×2·6	40×34×2·7	40×34×4·1	43×37×4·2

The assumed load (W) is the safe central load by British Standard Specification formula (hinged ends), as tabulated on pages 87, 89, for a height of 12 feet. The areas of the bases are as nearly as possible W/P.

The thickness of the slab is calculated for the assumed load (W) by the formulæ on page 150.

For further details, see Table B and typical drawings overleaf.

Poles, Piles.
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Rivets, Bolts.
Roofs, Concrete
Welding
Plates, Inertia.
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

SLAB BASES—Continued.

TABLE B. Approximate Weights, etc.

Size of Column.			Flange Cleats.		Web Cleats.		Weight of Base (approx.)			
Nominal.		Actual.	Size.	m	Size.	n	B.S.S.		L.C.C.	
							40 T	35 T	35 T	30 T
Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Lb.	Lb.	Lb.	Lb.
10 × 10	103	10·8 × 10·1	6 × 4 × ½	6	...	...	464	514	729	861
11 × 11	135	12·2 × 11·4	,,	7	...	...	673	784*	1158	1338*
12 × 12	59	11·4 × 11·7	,,	7½	...	...	178	200*	331	374
,,	81	11·8 × 11·8	,,	7½	...	...	311	347	524	605
,,	158	13·2 × 12·2	,,	8	...	...	887*	1079	1512	1776
14 × 12	76	13·7 × 11·7	,,	7½	...	...	251	281	444	515
,,	101	14·2 × 11·8	,,	7½	...	...	372*	481	703	892
,,	170	15·4 × 12·2	,,	8	...	...	936*	1075*	1640	1914
16 × 12	85	15·3 × 11·7	6 × 4 × ½	7½	4 × 4 × ½	11	307	339	522*	651
,,	110	15·7 × 11·8	6 × 4 × ⅝	7½	4 × 4 × ⅝	11	502	568*	814*	988
,,	172	16·9 × 12·1	,,	8	,,	11	1000	1111	1674	1949*
18 × 12	96	17·2 × 11·7	,,	7½	,,	12	353*	451	663*	813
,,	122	17·7 × 11·8	,,	7½	,,	12	551	619	956*	1186
,,	175	18·7 × 12·0	,,	8	,,	12	914*	1140	1718	1996

This table is to be read in conjunction with Figs. 2–4. The tabulated weights include the cleats, rivet heads, and bolts (countersunk on underside) shown in Figs. 2–4. All rivets and bolts are ⅞″ diameter.

In computing these weights, the thickness of the slab is assumed to be the nearest round figure (in fourths of an inch) *above* the theoretical thickness as given in Table A, except those marked with an asterisk, for which the theoretical thickness is less than 1/16″ above the nearest round figure ; in these cases the *nearest* round figure is assumed. See also notes on page 151 regarding commercial thicknesses and machining.

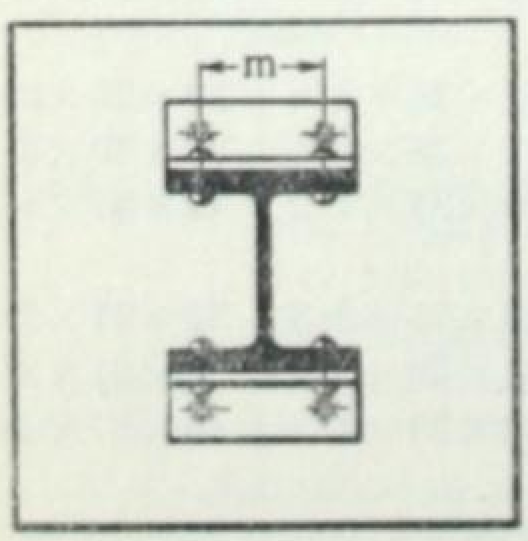

Fig. 2.

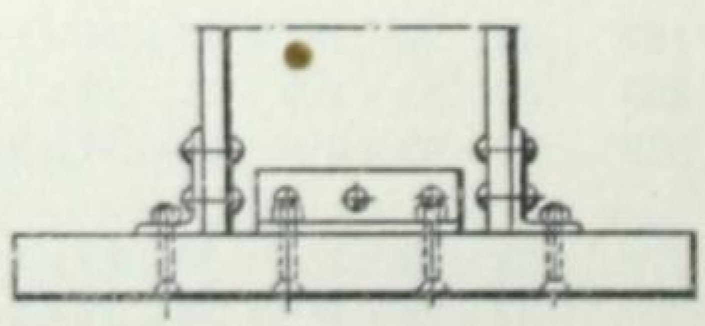

Fig. 4.

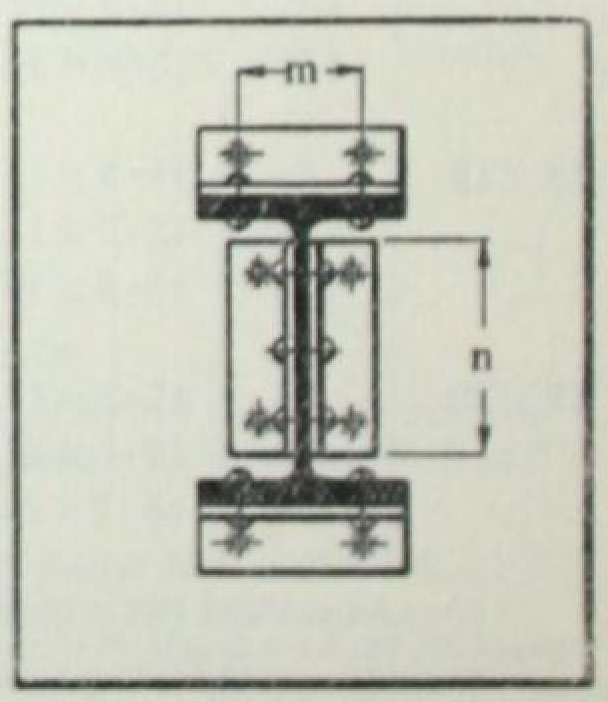

Fig. 3.

BROAD FLANGE BEAMS AS POLES.

PILING.

Poles, Piles.

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Rivets, Bolts.

Roofs, Concrete

Welding

Plates, Inertia.

Tests, Extras.

Weights, Measures

Math. tables.

Index, Code.

BROAD FLANGE BEAMS, GREY PROCESS, AS POLES AND STANDARDS.

Broad Flange Beams, Grey Process, are very suitable for electric power, telegraph, and telephone poles, railway signals, lamp standards, tram and trolley-bus standards, and railway electrification, and are extensively employed for these purposes. A typical electric railway portal structure is illustrated on page 160, and various simple connections for standards on pages 162 to 164.

Comparison with other types of poles—reinforced concrete, timber, and steel (latticed or tubular)—shows the superiority of the wide-flanged steel beams within the limits of their capacity.

The ordinary rolled steel joist is unsuitable owing to its relatively narrow flanges, and consequent weakness about the YY axis. Broad Flange Beams, Grey Process, are usually adequate in this respect; but where necessary, the various sections from 4″ to 8″ can be supplied with extra wide flanges (see table on page 164).

Though heavier than tubular or latticed poles, B.F. Beams are cheaper, owing to the higher price of tubes, and the fabricating costs of latticed poles. The economy of the B.F. Beams is still greater in the long run, owing to their longer life, as they are easily painted all over, and the metal is thicker.

They can be delivered with the utmost speed, owing to the very little work to be done on them after rolling, and they can be rolled at the rate of 500 to 1,000 tons a day.

They occupy less ground space than latticed poles—an important consideration in large towns; and owing to their square shape and clean square edges, they are in fact less unsightly than round poles. The ends can readily be shaped in the manner shown on pages 163 and 164, Figs. *f* and *i*.

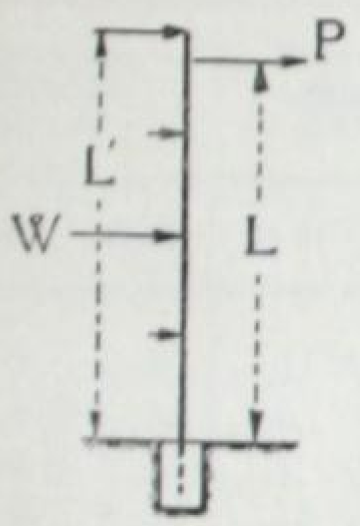
Their wide parallel flanges offer the utmost facility for all requisite connections; and unlike tubular and concrete poles, they are easily climbed by means of simple climbing irons of special form.

The fact that these beams are of uniform section, instead of tapering towards the top, means surplus material; this, as pointed out above, is more than compensated for by the low cost per ton. But if preferred (on the score of appearance), poles can be made with Broad Flange Beams of diminishing section, by the Acma system, as illustrated on page 161.

These beams can be rolled in any lengths required. Lengths up to about 40 feet can be galvanized, if required; but this adds considerably to the cost. At far less cost, they can be rendered partially immune to corrosion by a small addition of copper (see " Tests, Extras ").

B.F. BEAMS, GREY PROCESS, AS POLES.—Continued.

CALCULATION OF SAFE LOADS.



If f = Safe stress, in tons per sq. inch.
L = effective length of pole, as in sketch, in feet,
L′ = length exposed to wind, in feet,
w′ = wind pressure, in lb. per sq. foot,
B = width of pole, in feet,
Z_x = section modulus of the pole (loaded in the plane of the web),
P = safe dead load (i.e., *nett* safe load), in pounds,

Then $P = 2240 \dfrac{Z_x . f}{12. L} - \frac{1}{2} w'BL'$.

The safe loads tabulated on pages 156 and 157 below are calculated on this basis (taking L and L′ as equal).

TABLE A. In this table (page 156), the safe stress (f) is taken as $7\frac{1}{2}$ tons per sq. inch for dead load, allowing this to be exceeded for wind pressure (taken as 25 lb. per sq. foot) up to 9 tons per sq. inch.*

TABLE B. The alternative Table B (page 157) is designed to conform with the Electricity Commissioners' Overhead Line Regulations. Accordingly, the wind pressure is taken as 8 lb. per sq. foot, and the total stress limited to two-fifths of the calculated elastic limit of 15·6 tons per sq. inch (60% of an assumed ultimate tensile strength of 26 tons per sq. inch minimum).

By this formula, we have $P = 1167\, Z_x/L - 4\ BL$.

QUALITY OF STEEL.

The tabulated safe loads are appropriate to our 'Standard' quality of steel, viz., 26 tons minimum tensile (see page 267).

If the British Standard grade is employed (28/33 tons tensile), the loads in Table B can be increased by one-thirteenth.

DEFLECTION.

In each table, loads to the right of the zig-zag line, when combined with the specified wind pressure (25 and 8 lb. respectively) produce a deflection exceeding 1/4″ per foot of height, which in some cases may be objectionable. The deflection corresponding to any given load can be ascertained by reference to the deflection tables on pages 158, 159. These tables are calculated by the usual formulæ, and assume an elastic modulus of 13,000 tons per sq. inch.

DIMENSIONS.

The sizes given in these two tables are the 'nominal' sizes; for the 'exact' dimensions, see table on pages 16–20.

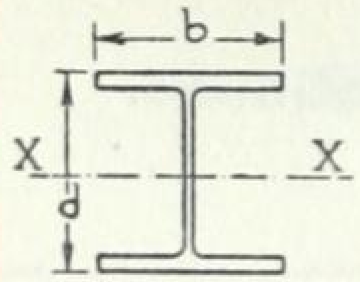
WEIGHTS.

Safe loads are given in these tables for sections up to 12″ × 12″ in each of the three weights which can be supplied without limitation as to quantity, viz.:—

The Die (minimum) weights, marked *e* in the tables,
the Dil (reduced web) ,, ,, *l* ,, ,,
the Din (medium) ,, ,, *n* ,, ,,

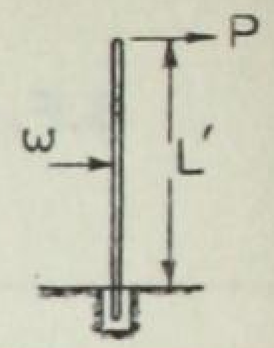
The Die weights will usually be found the most advantageous. As may be seen from the table on pages 16–20, all of these sections can, when required, be rolled either to greater weights or to intermediate weights, subject to the conditions as to minimum tonnage specified on page 286.

* The effect is that the tabulated values of P, up to the zig-zag line, correspond to $1400\ Z_x/L$, *or* ($1680\ Z_x/L - 12\frac{1}{2}\ BL$), whichever formula gives the lower value



B.F. BEAMS, GREY PROCESS, AS POLES.—Continued.

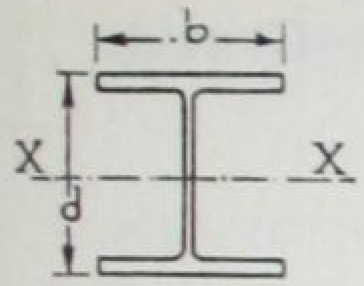
Table A.



Section Modulus. (Ins.³)		Nominal Size. (Ins.)	Weight per Foot.	Safe Load P (XX Axis) in Pounds.								
XX	YY	d × b	lb.	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	55 ft.
4·2	1·60	4 × 4	11·0 *e*	397	276	184	...	...	...	...	...	...
5·8	2·24	4 × 4	14·8 *n*	544	408	289	...	...	...	...	...	...
6·4	2·31	5 × 5	13·2 *e*	597	440	308	...	...	...	...	...	...
9·3	3·29	5½ × 5½	16·4 *e*	868	651	484	352	...	...	...	...	...
10·9	3·78	6 × 6	17·6 *e*	1017	763	581	429	...	...	...	...	...
12·9	4·58	6¼ × 6¼	20·0 *e*	1204	903	706	528	393	...	...	...	...
12·9	4·76	5½ × 5½	21·1 *l*	1204	903	722	550	418	...	...	...	...
13·2	4·82	5½ × 5½	23·4 *n*	1232	924	738	567	433	...	...	...	...
15·0	5·49	6 × 6	22·8 *l*	1400	1050	840	657	505	384	...	...	...
15·4	5·49	6 × 6	24·9 *n*	1437	1078	862	677	524	401	...	...	...
18·4	6·77	6¼ × 6¼	26·3 *l*	1717	1288	1030	833	653	511	...	...	...
18·5	6·34	7 × 7	24·8 *e*	1727	1295	1036	817	633	...	...	...	...
20·1	7·32	6¼ × 6¼	30·8 *n*	1876	1407	1125	929	735	582	...	...	...
24·9	8·72	8 × 8	30·1 *e*	2324	1743	1394	1150	911	721	...	...	...
25·3	9·28	7 × 7	31·9 *l*	2361	1771	1417	1181	955	767	611	...	...
26·0	9·21	7 × 7	34·7 *n*	2427	1820	1455	1213	989	796	639	...	...
32·0	11·0	8½ × 8½	34·5 *e*	2987	2240	1790	1492	1226	990	797	...	...
33·6	12·2	8 × 8	38·0 *l*	3136	2352	1882	1568	1326	1083	885	719	...
36·3	13·1	8 × 8	43·6 *n*	3388	2541	2032	1694	1452	1197	986	810	..
41·2	14·3	9½ × 9½	40·9 *e*	3845	2884	2307	1923	1639	1342	1102	900	...
43·6	15·7	8½ × 8½	44·6 *l*	4069	3052	2442	2035	1744	1470	1222	1014	...
44·7	15·7	8½ × 8½	48·0 *n*	4172	3129	2503	2086	1788	1516	1263	1051	...
46·7	16·2	10 × 10	44·2 *e*	4359	3269	2615	2180	1868	1557	1288	1064	...
50·9	17·4	10¼ × 10¼	46·0 *e*	4751	3563	2850	2375	2035	1718	1427	1184	...
55·5	19·9	9½ × 9½	51·9 *l*	5180	3885	3108	2590	2220	1937	1629	1373	1153
59·4	21·1	9½ × 9½	58·7 *n*	5544	4158	3326	2772	2375	2079	1774	1504	1272
61·0	21·0	11 × 11	51·4 *e*	5693	4270	3415	2847	2440	2108	1766	1482	1239
62·1	22·2	10 × 10	55·6 *l*	5796	4347	3478	2898	2484	2173	1857	1575	1333
64·9	22·9	10 × 10	61·1 *n*	6057	4543	3634	3028	2596	2271	1962	1669	1418
69·1	24·7	10¼ × 10¼	59·5 *l*	6449	4837	3870	3225	2764	2419	2100	1789	1524
70·7	24·8	10¼ × 10¼	63·6 *n*	6599	4949	3959	3299	2828	2474	2160	1842	1573
75·8	26·0	12 × 12	58·9 *e*	7075	5306	4245	3537	3032	2653	2281	1937	1645
84·9	30·3	11 × 11	67·7 *l*	7924	5943	4754	3962	3362	2971	2641	2277	1963
90·3	31·9	11 × 11	75·7 *n*	8428	6321	5057	4214	3612	3160	2808	2460	2128
103	36·6	12 × 12	76·4 *l*	9613	7210	5768	4807	4120	3605	3204	2846	2470
105	36·6	12 × 12	81·2 *n*	9800	7349	5880	4900	4200	3675	3266	2913	2530

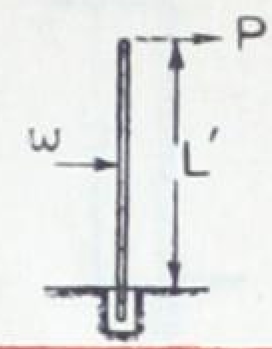
For notes and mode of calculation, see p. 155.

Loads to the right of the zig-zag line produce, with the specified wind pressure, a deflection exceeding 1/4″ per foot of height.



B.F. BEAMS, GREY PROCESS, AS POLES.—Continued.

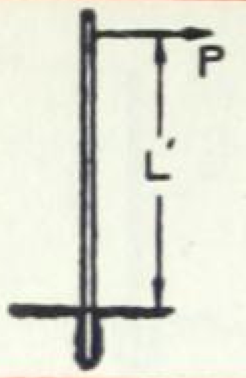
Table B.



Section Modulus. (Ins.³)		Nominal Size. (Ins.)	Weight per Foot.	Safe Load P (XX Axis) in Pounds.								
XX	YY	d × b	lb.	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	55 ft.
4·2	1·60	4 × 4	11·0 *e*	312	222	166	...	...	...	...	...	...
5·8	2·24	4 × 4	14·8 *n*	434	314	239	188	...	...	...	...	...
6·4	2·31	5 × 5	13·2 *e*	474	342	260	202	...	...	...	...	...
9·3	3·29	5½ × 5½	16·4 *e*	696	507	389	308	247	...	...	...	...
10·9	3·78	6 × 6	17·6 *e*	819	597	461	366	295	241	...	...	...
12·9	4·58	6¼ × 6¼	20·0 *e*	972	711	550	439	358	293	...	...	...
12·9	4·76	5½ × 5½	21·1 *l*	975	715	555	446	366	...	...	...	...
13·2	4·82	5½ × 5½	23·4 *n*	999	733	570	458	376	...	...	...	...
15·0	5·49	6 × 6	22·8 *l*	1137	836	651	524	431	358	...	...	...
15·4	5·49	6 × 6	24·9 *n*	1168	859	670	540	444	...	...	...	...
18·4	6·77	6¼ × 6¼	26·3 *l*	1400	1031	807	652	539	452	...	...	...
18·5	6·34	7 × 7	24·8 *e*	1404	1032	805	649	535	446	...	...	...
20·1	7·32	6¼ × 6¼	30·8 *n*	1532	1130	886	719	596	502	...	...	...
24·9	8·72	8 × 8	30·1 *e*	1898	1400	1097	890	739	622	...	...	...
25·3	9·28	7 × 7	31·9 *l*	1932	1429	1122	913	760	644	550	...	...
26·0	9·21	7 × 7	34·7 *n*	1986	1470	1154	940	784	664	568	...	...
32·0	11·0	8½ × 8½	34·5 *e*	2447	1810	1422	1159	968	820	702	...	...
33·6	12·2	8 × 8	38·0 *l*	2573	1908	1502	1228	1028	875	753	...	...
36·3	13·1	8 × 8	43·6 *n*	2783	2065	1630	1333	1118	954	823	...	...
41·2	14·3	9½ × 9½	40·9 *e*	3158	2342	1844	1509	1265	1078	929	806	...
43·6	15·7	8½ × 8½	44·6 *l*	3346	2485	1963	1609	1352	1156	1000	873	...
44·7	15·7	8½ × 8½	48·0 *n*	3432	2550	2014	1651	1389	1188	1029	899	...
46·7	16·2	10 × 10	44·2 *e*	3583	2660	2098	1719	1439	1231	1065	927	...
50·9	17·4	10¼ × 10¼	46·0 *e*	3908	2902	2291	1878	1579	1350	1169	1020	...
55·5	19·9	9½ × 9½	51·9 *l*	4270	3174	2511	2064	1740	1493	1297	1138	...
59·4	21·1	9½ × 9½	58·7 *n*	4573	3402	2693	2216	1870	1606	1398	1229	1087
61·0	21·0	11 × 11	51·4 *e*	4690	3485	2756	2263	1906	1634	1418	1242	1094
62·1	22·2	10 × 10	55·6 *l*	4781	3556	2816	2317	1955	1680	1462	1285	1137
64·9	22·9	10 × 10	61·1 *n*	4999	3720	2947	2426	2048	1762	1534	1350	1197
69·1	24·7	10¼ × 10¼	59·5 *l*	5323	3963	3140	2585	2184	1878	1637	1441	1278
70·7	24·8	10¼ × 10¼	63·6 *n*	5448	4056	3214	2647	2238	1925	1679	1479	1312
75·8	26·0	12 × 12	58·9 *e*	5838	4344	3440	2831	2391	2055	1790	1574	1394
84·9	30·3	11 × 11	67·7 *l*	6548	4879	3870	3192	2701	2329	2036	1798	1599
90·3	31·9	11 × 11	75·7 *n*	6968	5194	4122	3402	2881	2487	2176	1924	1713
103	36·6	12 × 12	76·4 *l*	7952	5929	4709	3888	3295	2847	2493	2206	1969
105	36·6	12 × 12	81·2 *n*	8108	6046	4802	3965	3362	2906	2545	2253	2011

For mode of calculation, see p. 155.

Loads to the right of the zig-zag line produce, with the specified wind pressure, a deflection exceeding 1/4" per foot of height.



B.F. BEAMS, GREY PROCESS, AS POLES.—Cont'd.

Table C.

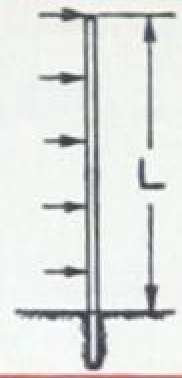
DEFLECTION PER 1,000 LB. OF LOAD.

Nominal Depth.	Weight per ft.	Cantilever length.								
		15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	55 ft.
Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
4	11·0 *e*	8·44	20·01	39·08	...	...	...	...	...	...
4	14·8 *n*	5·80	13·75	26·85	...	...	...	...	...	...
5	13·2 *e*	4·63	10·98	21·44	37·05	...	...	...	...	...
5½	16·4 *e*	2·72	6·45	12·63	21·78	34·58	...	...	...	...
6	17·6 *e*	2·18	5·17	10·09	17·44	27·69	41·33	...	...	...
6¼	20·0 *e*	1·75	4·15	8·11	14·01	22·24	33·20	...	...	...
5½	21·1 *l*	1·88	4·45	8·70	15·03	23·87	35·63	...	...	...
5½	23·4 *n*	1·82	4·32	8·44	14·58	23·15	34·56	...	...	...
6	22·8 *l*	1·51	3·57	6·97	12·04	19·13	28·55	...	...	...
6	24·9 *n*	1·46	3·47	6·77	11·70	18·58	27·73	...	...	...
6¼	26·3 *l*	1·15	2·72	5·31	9·17	14·56	21·73	...	...	...
7	24·8 *e*	1·07	2·52	4·93	8·52	13·53	20·20	...	...	...
6¼	30·8 *n*	1·05	2·50	4·88	8·43	13·38	19·98	...	...	...
8	30·1 *e*	·72	1·70	3·32	5·73	9·10	13·58	...	...	...
7	31·9 *l*	·74	1·76	3·45	5·95	9·46	14·12	20·10	...	...
7	34·7 *n*	·72	1·72	3·35	5·79	9·21	13·73	19·56	...	...
8½	34·5 *e*	·50	1·19	2·32	4·01	6·37	9·51	13·54	...	...
8	38·0 *l*	·50	1·19	2·32	4·01	6·37	9·51	13·54	18·57	...
8	43·6 *n*	·47	1·11	2·16	3·73	5·92	8·84	12·59	17·27	...
9½	40·9 *e*	·36	·85	1·66	2·87	4·56	6·80	9·68	13·26	...
8½	44·6 *l*	·35	·84	1·63	2·82	4·49	6·69	9·53	13·07	...
8½	48·0 *n*	·35	·82	1·60	2·76	4·39	6·55	9·33	12·80	...
10	44·2 *e*	·30	·72	1·40	2·42	3·84	5·73	8·15	11·18	...
10¼	46·0 *e*	·27	·63	1·24	2·13	3·39	5·06	7·20	9·88	...
9½	51·9 *l*	·25	·60	1·18	2·04	3·23	4·83	6·87	9·43	12·55
9½	58·7 *n*	·24	·56	1·10	1·90	3·02	4·50	6·41	8·79	11·70
11	51·4 *e*	·21	·49	·96	1·67	2·65	3·95	5·63	7·72	10·27
10	55·6 *l*	·22	·52	1·01	1·74	2·77	4·13	5·88	8·07	10·74
10	61·1 *n*	·21	·49	·96	1·67	2·65	3·95	5·63	7·72	10·27
10¼	59·5 *l*	·19	·45	·87	1·50	2·39	3·57	5·09	6·98	9·29
10¼	63·6 *n*	·18	·44	·85	1·47	2·34	3·49	4·97	6·82	9·08
12	58·9 *e*	·15	·37	·71	1·24	1·98	2·93	4·18	5·73	7·63
11	67·7 *l*	·14	·34	·66	1·14	1·81	2·70	3·85	5·28	7·03
11	75·7 *n*	·13	·32	·62	1·07	1·71	2·54	3·63	4·96	6·62
12	76·4 *l*	·11	·26	·51	·88	1·40	2·08	2·97	4·07	5·42
12	81·2 *n*	·11	·26	·50	·86	1·37	2·04	2·91	3·99	5·31

To obtain total deflection, add for wind pressure, with aid of table opposite. For notes, see pages 154, 155.

B.F. BEAMS, GREY PROCESS, AS POLES.—Cont'd.

Table D.



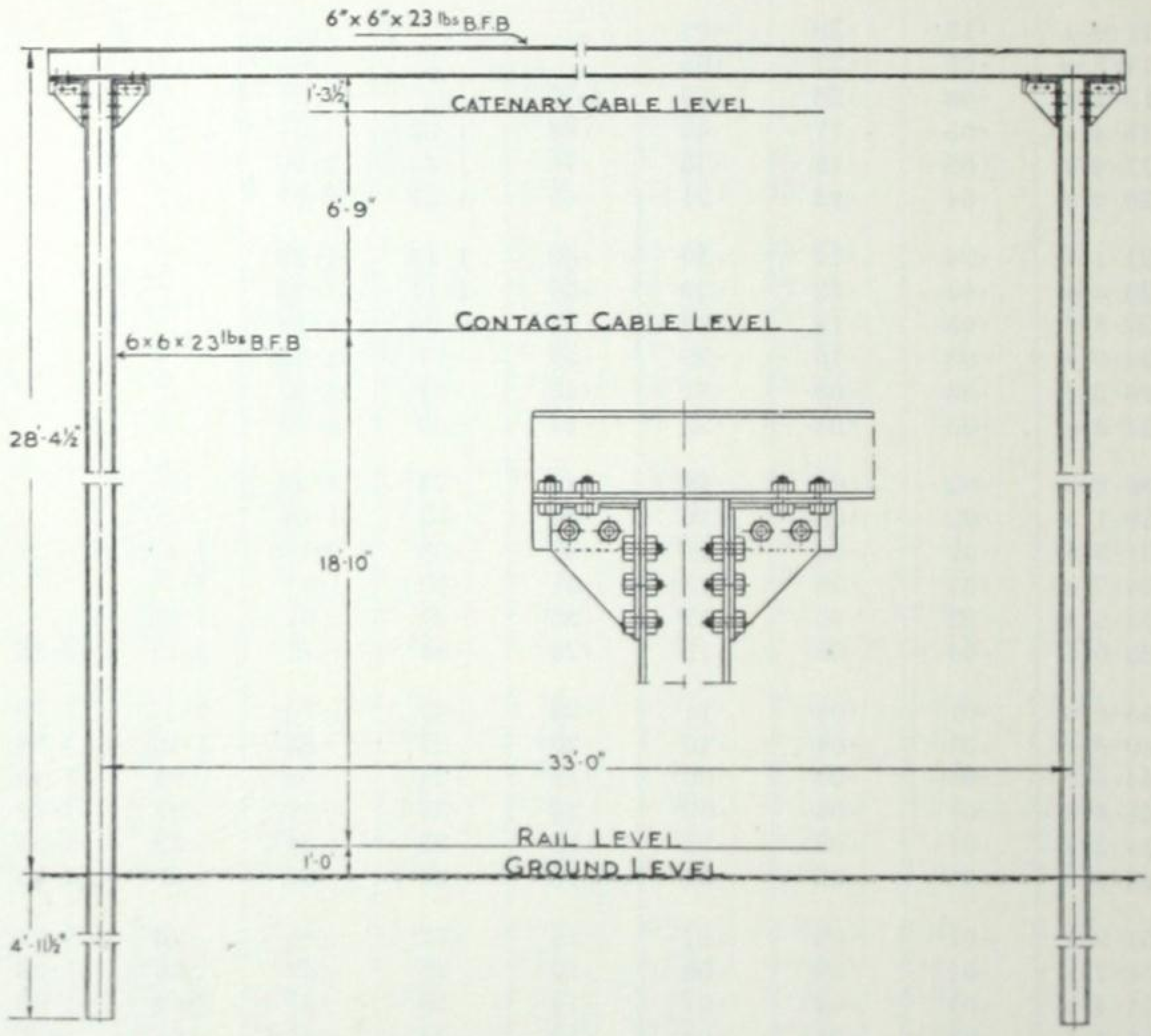
DEFLECTION UNDER WIND PRESSURE OF 8 LB. PER SQ. FOOT.

Nominal Depth.	Weight per ft.	Exposed length								
		15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	55 ft.
Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
4	11·0 *e*	·12	·39	·95	...	...	...	...	...	...
4	14·8 *n*	·08	·27	·65	...	...	...	...	...	...
5	13·2 *e*	·08	·26	·63	1·31	...	...	...	...	...
5½	16·4 *e*	·05	·17	·42	·88	1·63	...	...	...	...
6	17·6 *e*	·05	·15	·36	·76	1·40	2·40	...	...	...
6½	20·0 *e*	·04	·13	·31	·65	1·22	2·07	...	...	...
5½	21·1 *l*	·04	·12	·30	·62	1·14	1·98	...	...	...
5½	23·4 *n*	·04	·12	·29	·60	1·11	1·92	...	...	...
6	22·8 *l*	·03	·10	·26	·54	1·00	1·68	...	...	...
6	24·9 *n*	·03	·10	·25	·52	·97	1·63	...	...	...
6½	26·3 *l*	·03	·08	·21	·43	·81	1·37	...	...	...
7	24·8 *e*	·03	·08	·22	·44	·83	1·41	...	...	...
6½	30·8 *n*	·02	·08	·19	·40	·74	1·26	...	...	...
8	30·1 *e*	·02	·06	·16	·34	·62	1·06	...	...	...
7	31·9 *l*	·02	·06	·15	·32	·59	1·00	1·61	...	...
7	34·7 *n*	·02	·06	·15	·31	·57	·97	1·56	...	...
8½	34·5 *e*	·02	·05	·12	·26	·47	·81	1·30	...	...
8	38·0 *l*	·01	·05	·12	·24	·44	·75	1·21	1·83	...
8	43·6 *n*	·01	·04	·11	·22	·41	·70	1·12	1·70	...
9½	40·9 *e*	·01	·04	·10	·20	·37	·63	1·02	1·54	...
8½	44·6 *l*	·01	·04	·09	·19	·34	·59	·94	1·42	...
8½	48·0 *n*	·01	·04	·09	·18	·34	·57	·92	1·39	...
10	44·2 *e*	·01	·03	·08	·18	·33	·56	·89	1·35	...
10½	46·0 *e*	·01	·03	·08	·16	·30	·51	·82	1·25	...
9½	51·9 *l*	·01	·03	·07	·14	·27	·45	·73	1·11	1·62
9½	58·7 *n*	·01	·03	·06	·13	·25	·42	·68	1·03	1·51
11	51·4 *e*	·01	·03	·07	·14	·25	·43	·69	1·05	1·55
10	55·6 *l*	·01	·03	·06	·13	·24	·41	·65	·99	1·45
10	61·1 *n*	·01	·02	·06	·12	·23	·37	·62	·95	1·38
10½	59·5 *l*	·01	·02	·06	·12	·22	·36	·59	·89	1·30
10½	63·6 *n*	·01	·02	·05	·11	·21	·36	·57	·87	1·28
12	58·9 *e*	·01	·02	·05	·11	·20	·34	·55	·85	1·23
11	67·7 *l*	·01	·02	·05	·09	·17	·30	·48	·73	1·06
11	75·7 *n*	·01	·02	·04	·09	·16	·28	·45	·68	1·00
12	76·4 *l*	...	·01	·04	·08	·14	·25	·39	·60	·88
12	81·2 *n*	...	·01	·04	·08	·14	·24	·39	·59	·86

The area exposed to wind is taken as Length × Flange width. For further explanation, see pages 154, 155.

B.F. BEAMS, GREY PROCESS: AS PORTALS.

GREAT INDIAN PENINSULA RAILWAY ELECTRIFICATION.

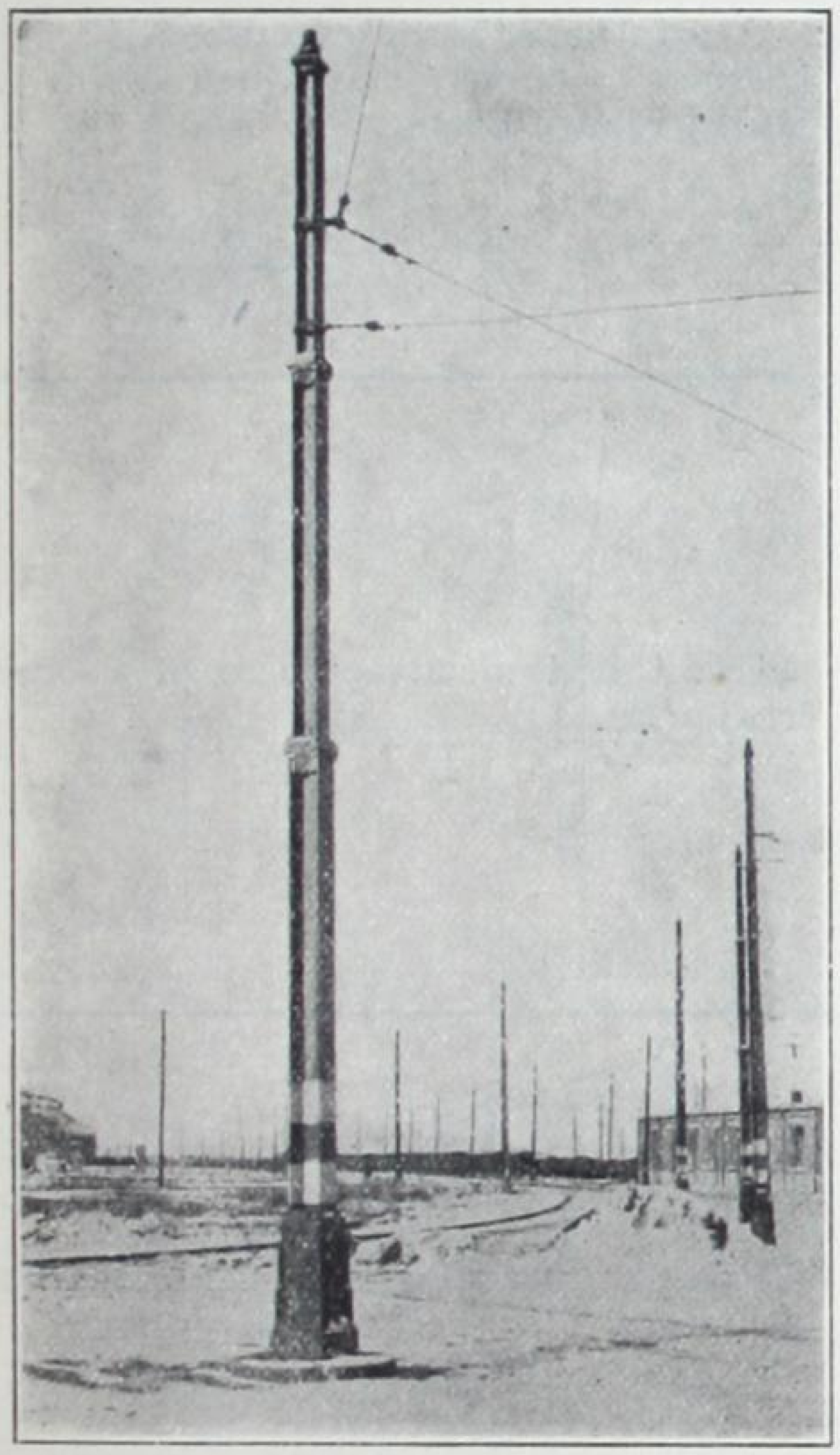


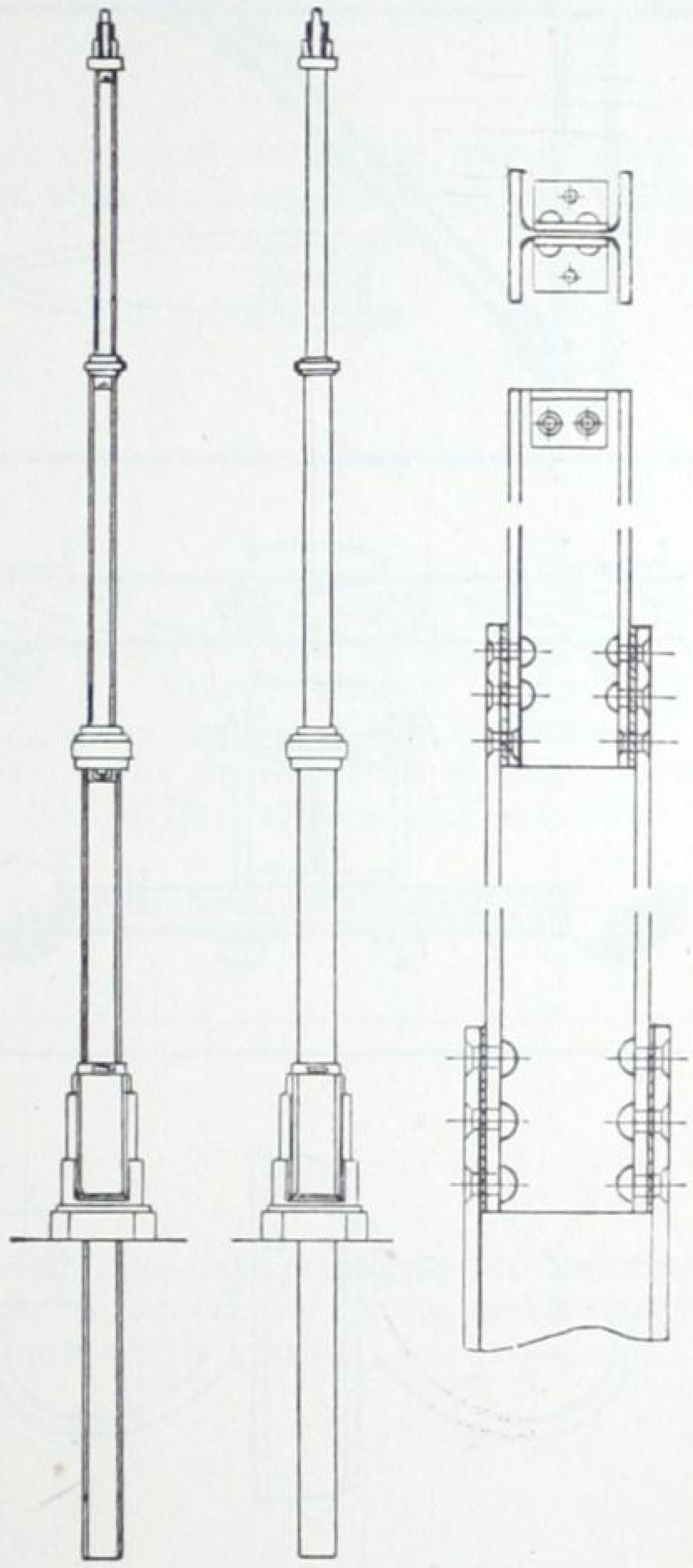
This drawing shows a structure of the portal type, double track, extensively employed in the electrification of the Great Indian Peninsula Railway, from Kalyan to Poona and Kalyan to Igatpuri.

Very similar structures are used in the more recent Central Brazilian Railway electrification, and in the new London & North Eastern Railway electrified systems, at present in course of construction.

B.F. BEAMS, GREY PROCESS : AS TAPERED POLES.

ACMA SYSTEM.

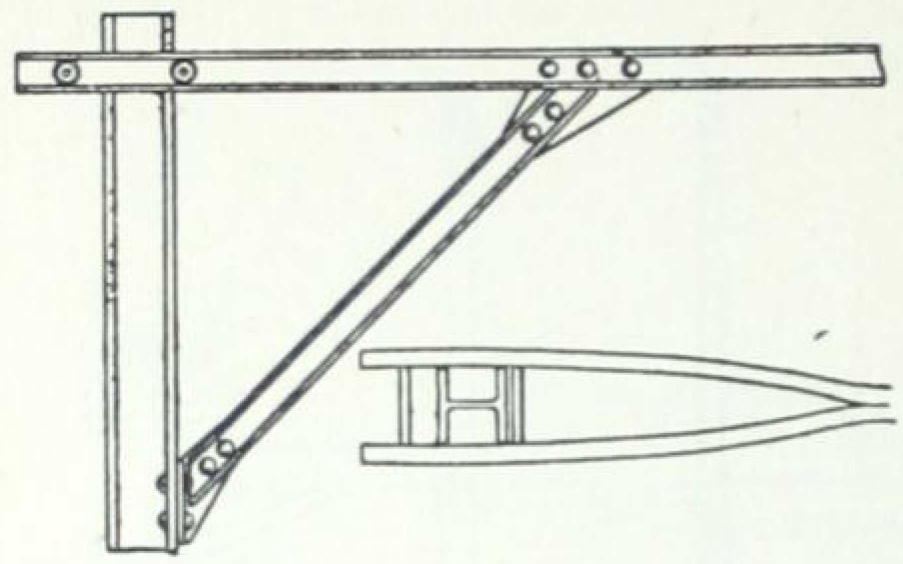
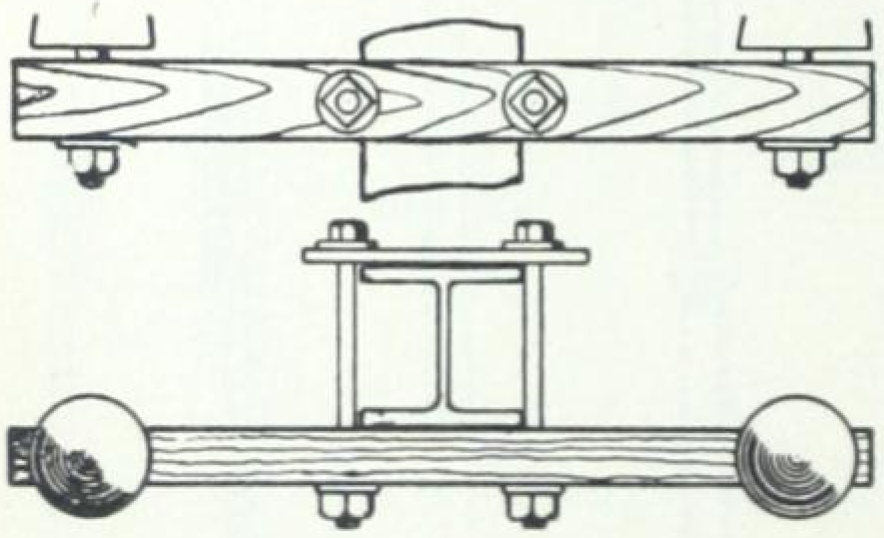
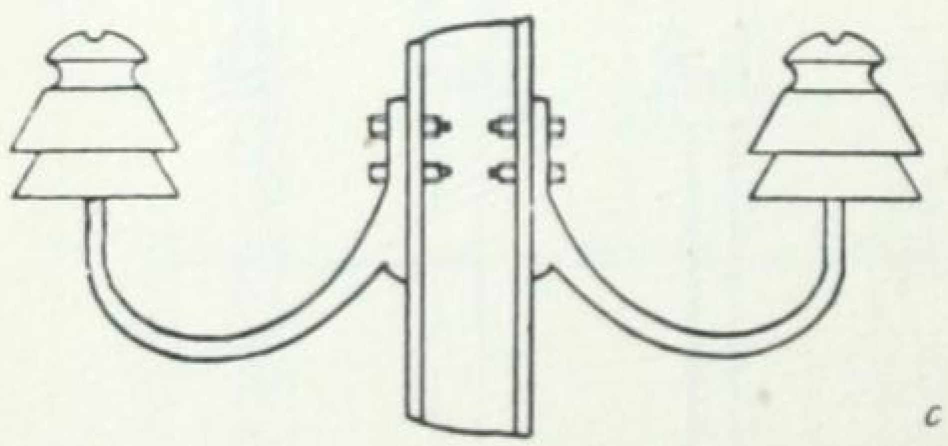
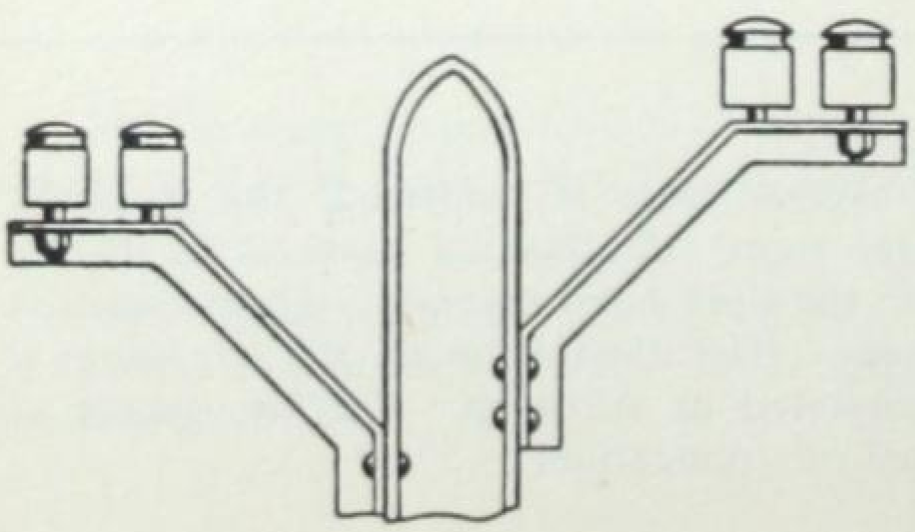




ACMA SYSTEM.—In those cases where a tapered pole is preferred, the patented Acma type is available. This consists of three (or more) diminishing sections of Broad Flange Beams. The mode of connection is shown in the right-hand diagram. Light cast-iron covers in two halves are clamp-bolted over the joint. The illustration on the left shows a portion of the new Trolley-Bus line recently completed at Antwerp. Further details of Acma lamp and tramway standards can be supplied on application.

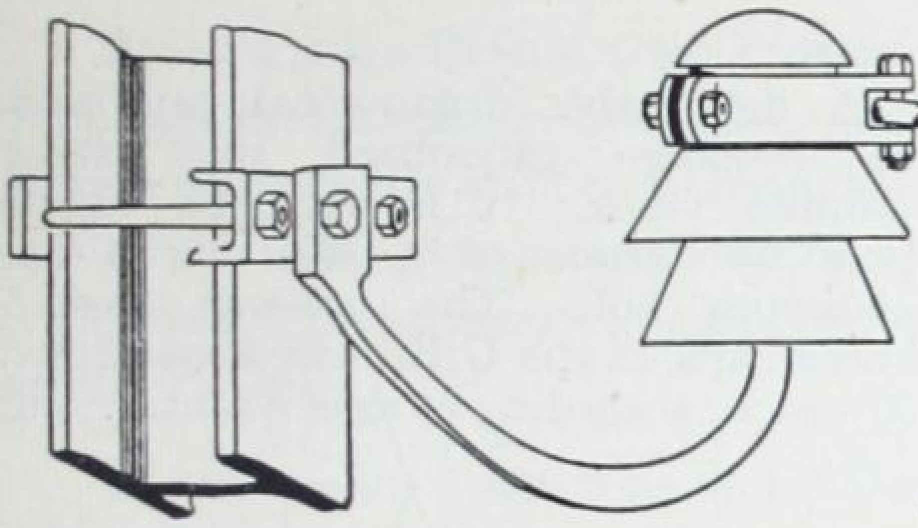
SOME FITTINGS FOR

BROAD FLANGE BEAMS, GREY PROCESS, AS POLES.

 a	A cantilever arm composed of two channel sections clamp-bolted to a Broad Flange Beam.
 b	Usual mode of attachment of wooden cross-arms.
 c	Forged brackets for low-tension insulators.
 d	Off-set arms composed of Tee sections.

SOME FITTINGS FOR

BROAD FLANGE BEAMS, GREY PROCESS, AS POLES.—Continued.



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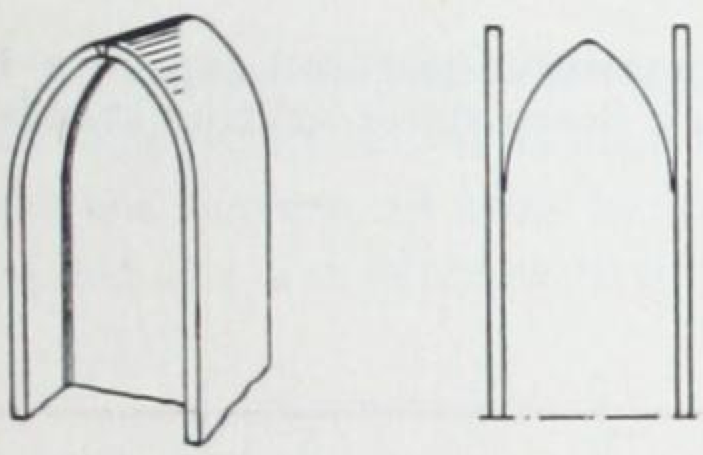
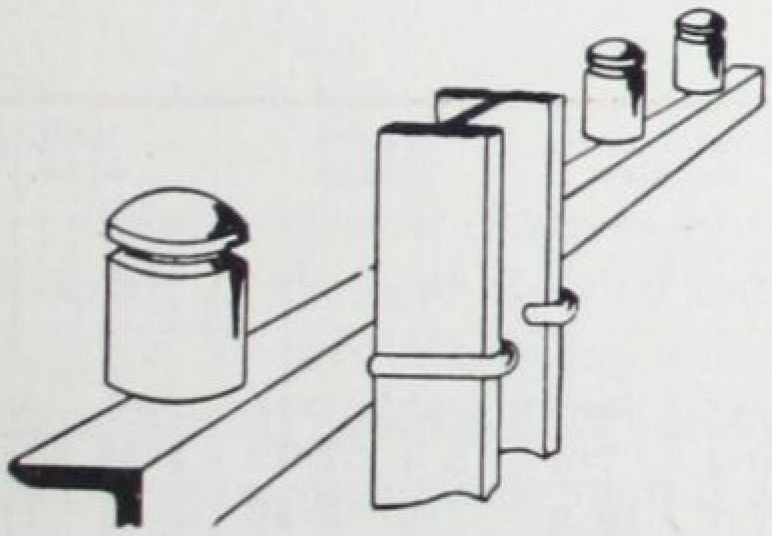
A mode of attaching forged steel or cast-iron brackets for Tramway work.



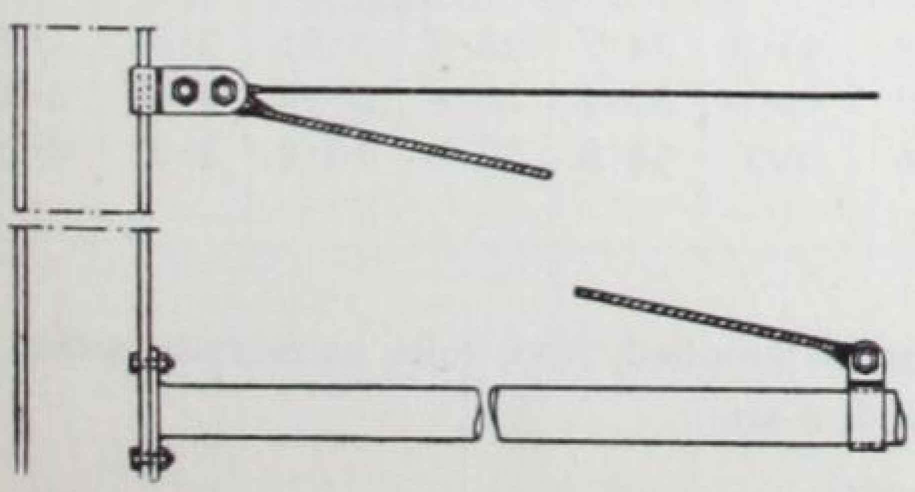
f

A simple method of forming pointed tops to Broad Flange Beams. The flanges are bent over and welded at their apex. The present cost of this is about 6s. 0d. to 12s. 0d. per end, according to size etc.



g

An angle-iron cross-bar for Telephone lines attached by hook bolts to the flanges of the pole.

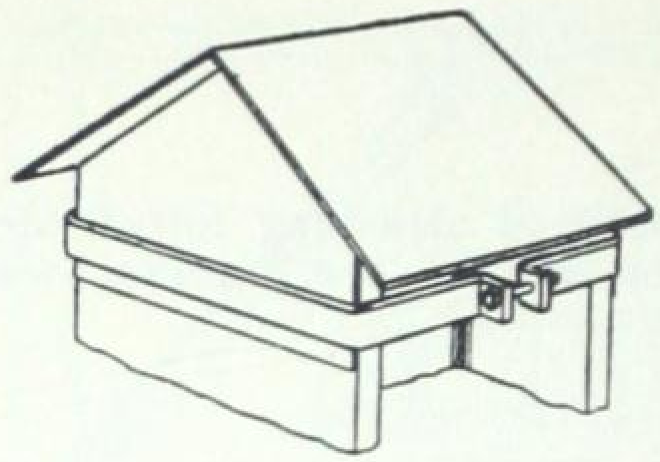


h

The cantilever arm of a Tramway standard supported by a steel cable. The arm is attached to the flange by four bolts, and the cable to a clamp on the flanges secured by a single pinch bolt.

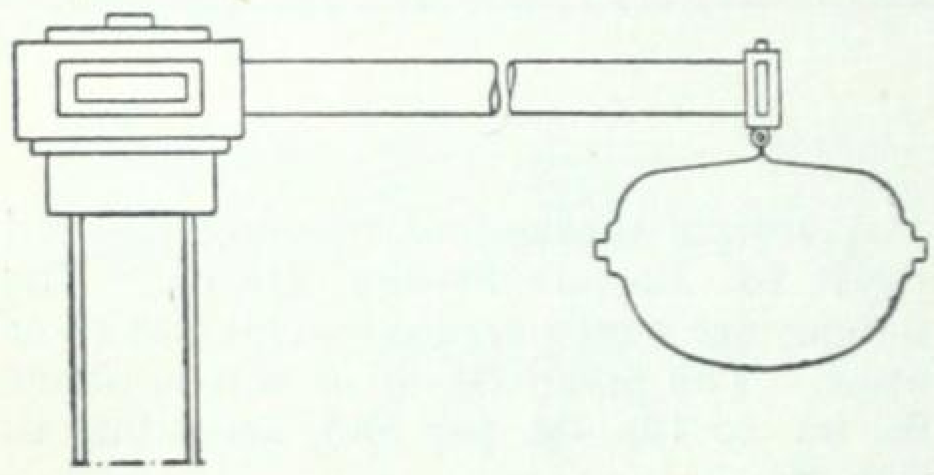
SOME FITTINGS FOR

BROAD FLANGE BEAMS, GREY PROCESS, AS POLES.—Continued.



i

A detachable ornamental cap made of 18-gauge galvanized steel sheet, painted black. It is attached to the pole by means of a steel strap and clamping bolt. The pre-war cost of these caps, in the U.K., was about 2/6 to 5/- each, according to size, quantity, etc.



j

Ornamental cast-iron cap on a Broad Flange Beam street-lighting standard.

SPECIAL SIZES OF B.F. BEAMS, GREY PROCESS, FOR USE AS POLES.

Nominal Depth.	Dimensions. d × b	Weight per Foot.	Code Word.	Thickness. Fl.	Thickness. Web.	Area. A	Moments of Inertia. I_x	Moments of Inertia. I_y	Section Moduli. Z_x	Section Moduli. Z_y	Radii of Gyration. g_x	Radii of Gyration. g_y
Ins.	Ins.	Lb.		Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
4	3·7×5·1	13·6	YUDOS	·31	·20	4·0	10·1	7·0	5·4	2·75	1·59	1·33
5	4·5×5·9	15·8	YUDPA	·31	·20	4·6	17·7	10·8	7·9	3·66	1·95	1·53
5½	5·2×6·7	19·3	YUDUT	·33	·22	5·7	29·6	16·7	11·3	5·00	2·29	1·72
6	5·6×7·1	20·4	YUDVY	·33	·22	6·0	36·6	19·9	13·0	5·60	2·47	1·82
6½	5·9×7·5	23·1	YUEGS	·35	·24	6·8	45·3	24·7	15·3	6·61	2·58	1·91
7	6·8×7·9	27·2	YUEMZ	·39	·26	8·0	69·9	32·1	20·6	8·14	2·96	2·00
8	7·5×8·7	32·8	YUERF	·43	·28	9·6	103	46·9	27·5	10·8	3·27	2·21

These special sections with extra-wide flanges can be supplied, from rolls, as readily as the standard sections if ordered in lots of at least 10 tons of a size.

Their safe loads as *stanchions* are given on page 92.

B.F. BEAMS AS PILES.

Broad Flange Beams, Grey Process, have been used extensively as piles ; notably in England, Hongkong, Shanghai, and Karachi. A large tonnage of the 12″ Die section was recently shipped to Shanghai in unjointed lengths up to 105 feet : the beams fulfilled the dual purpose of piles and superstructure legs in a large jetty. In case of need, to facilitate transport, the beams can be spliced as shown on page 166, or welded together at site.

In 1936, some 1,600 tons of 12″ Din were used as foundation piles for a slipway in a large North of England shipbuilding yard in lengths of 60 to 75 feet. Other frequent uses of these beams as piles have been for riverside wharves, warehouses, embankment strengthening, and king piles.

They can be pointed when necessary in the various ways shown in Figs. 1 to 3 below. The points shown in Figs. 1 and 2 cost about 6 to 8 shillings each. In Fig. 3 parts of the web are cut away by oxy-acetylene, the flanges bent over hot, and the tip arc-welded at a cost of about 10 to 12 shillings per point.

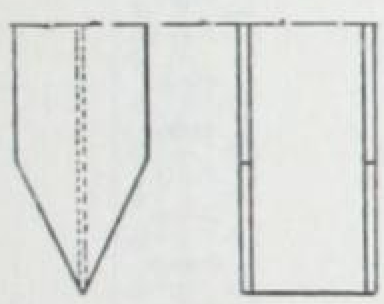


Fig. 1

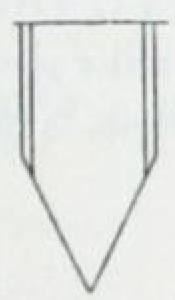


Fig. 2

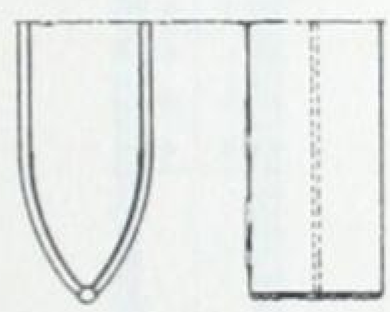
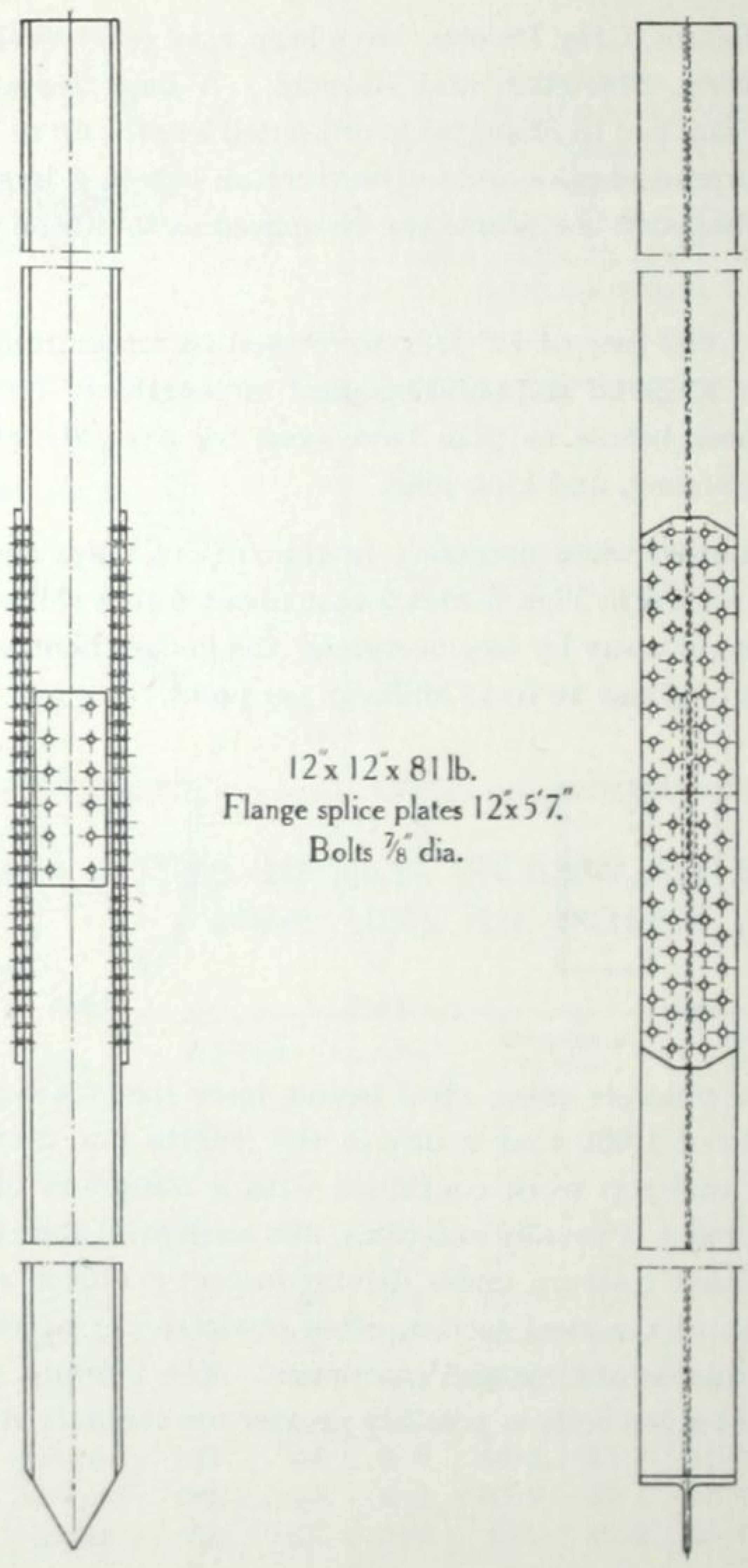


Fig. 3

Compared with concrete piles, steel beams have many advantages. They can be rolled at the rate of 1,000 tons a day in the lengths and section required ; and they can be driven and top work continued with a minimum of delay. The most simple driving equipment is usually sufficient, and with steel the risk of head or point shattering or undetected fracture under driving impact is almost excluded. Further, the inherent strength of the steel section often obviates the necessity of soil boring, with its attendant expense of time and equipment. The liability to deterioration in sea water or chemical-laden soils is possibly greater for concrete than for steel.

B.F. BEAM PILES.



The piles illustrated above are of B.F. Beams, Grey Process, 12″ × 12″ × 81 lb., as used in an extension to the Hong Kong & Kowloon Wharf.

The splicing is only required for convenience of shipment, as these beams can be rolled in lengths of 100 feet and more (see p. 287) and have in fact been shipped in lengths up to 105 feet.

SHEET PILING.

SHEET PILING.

Steel sheet piling, consisting of interlocking sections, is widely used for constructing coffer dams, retaining walls in docks and harbours, quays and wharves, river protection and sea defence works, etc.

In the Larssen system here illustrated, corners are formed by bending one of the standard sections as in Figs. 1 to 3, or by the addition of angles as in Fig. 4. Junctions are made with the aid of a half pile (split vertically down the centre) and with an angle added, as in Fig. 5, for example. The box pile shown in Fig. 6 is composed of two Larssen sections welded together: this type may be used in lieu of pre-cast concrete or timber piles.

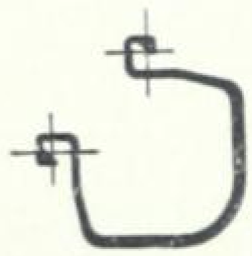


Fig. 1.

Fig. 2.

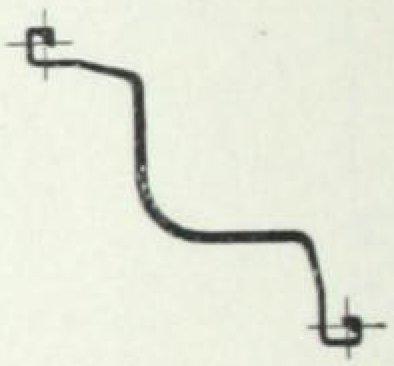


Fig. 3.

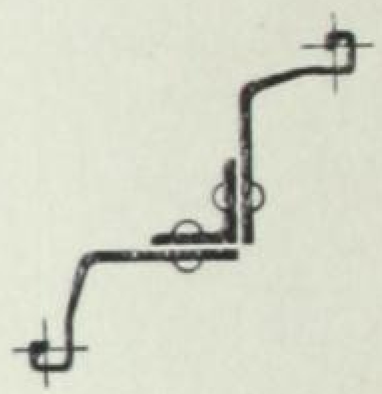


Fig. 4

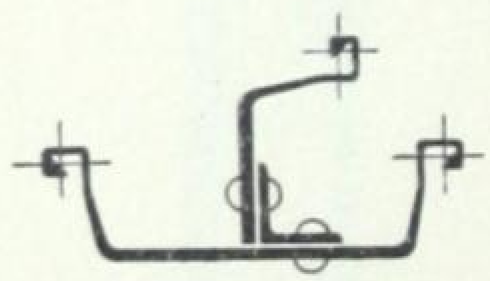


Fig. 5

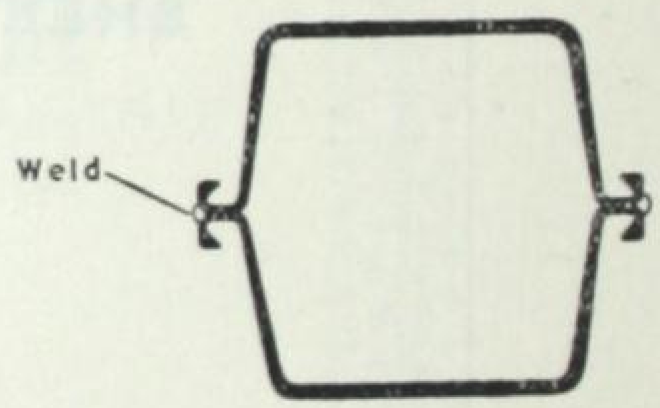


Fig. 6.

For permanent work, the steel should be coated with neutralized tar or other appropriate anti-corrosion composition before driving. The web thicknesses of certain of the sections can be increased if desired and if the required tonnage is sufficient to warrant it.

The Larssen piling is usually supplied in the ordinary British Standard grade (28/33 tons tensile), with or without copper. It can also be supplied in a rust-resisting steel of 36/40 tons tensile.

There is sufficient play in the interlock* to permit of the piling being driven to a fairly small radius—*e.g.*, sections up to No. 3 can be driven at an angle up to about 9°, enabling a complete circle to be formed with a minimum of about 40 piles; with the larger sections, the maximum angle is about 7°, and the minimum number to a circle would be 40 to 50. These sections have been rolled in lengths up to 100 feet.

The sheet piling may be left in position, withdrawn after use or cut off at or below the water-line by oxy-acetylene or oxy-hydrogen flame (if below the water-line).

---

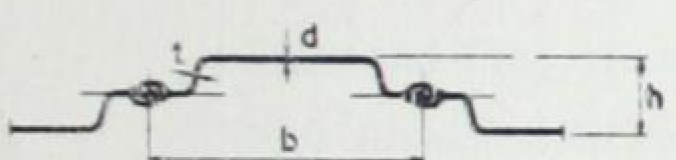
* The joints can usually be relied upon to become watertight automatically through the penetration of mud and silt.

PROPERTIES OF LARSSEN PILING.

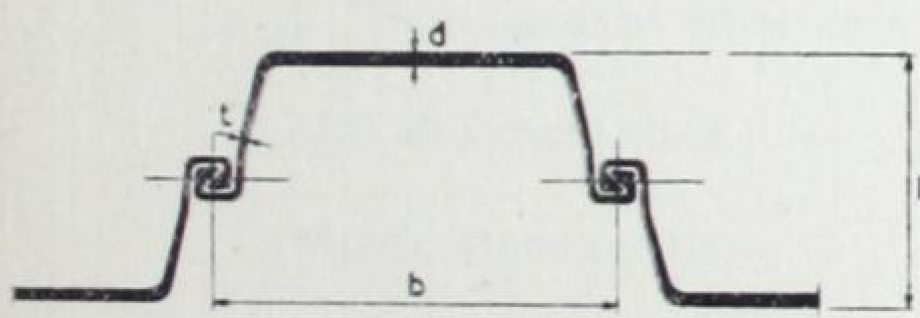
Key drawings below.

Section No.	Single Piles.				Per Foot of Wall.			
	Breadth.	Thickness.		Weight per foot.	Depth.	Weight per sq. ft.	Sectional Area.	Section Modulus.
	b	d	t		h			
	Ins.	Ins.	Ins.	lb.	Ins.	lb.	Ins².	Ins.³
OGB	$10\frac{13}{16}$	0·20	0·20	10·34	$2\frac{15}{16}$	11·47	3·37	2·2
IC	$13\frac{1}{2}$	0·25	0·25	16·28	$2\frac{1}{2}$	14·47	4·30	2·9
IGB	$15\frac{3}{4}$	0·32	0·23	24·30	$5\frac{1}{8}$	18·50	5·44	7·8
IU	$15\frac{3}{4}$	0·375	0·375	28·50	$5\frac{1}{8}$	21·70	6·38	9·1
2	$15\frac{3}{4}$	0·41	0·31	32·79	$7\frac{7}{8}$	24·98	7·35	15·8
3	$15\frac{3}{4}$	0·55	0·35	41·66	$9\frac{3}{4}$	31·74	9·33	25·3
4B	$16\frac{9}{16}$	0·63	0·43	56·75	$13\frac{1}{2}$	41·12	12·07	42·5
5*	$16\frac{9}{16}$	0·87	0·47	67·19	$13\frac{1}{2}$	48·74	14·34	55·1*
10A	$17\frac{3}{4}$	0·50	0·50	40·40	$7\frac{7}{8}$	27·30	8·03	11·7
2/10A	$15\frac{3}{4}/17\frac{3}{4}$	0·41/0·50	0·31/0·50	32·8/40·4	$4\frac{13}{16}$	26·30	7·73	6·9

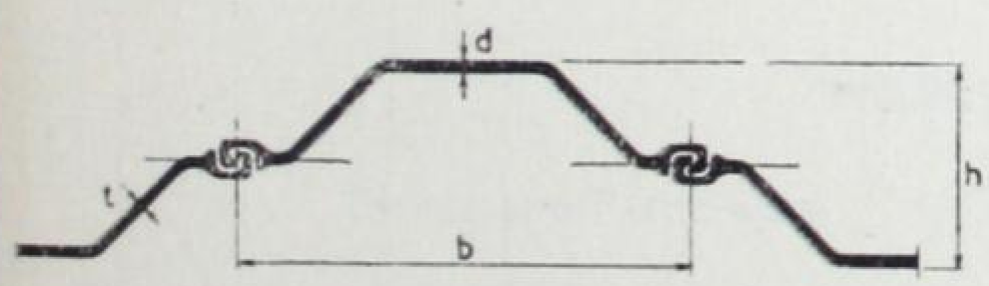
* The strength of section No. 5 can be increased as required in the region of the maximum bending moment by the provision of plates riveted or welded to the web of the pile.



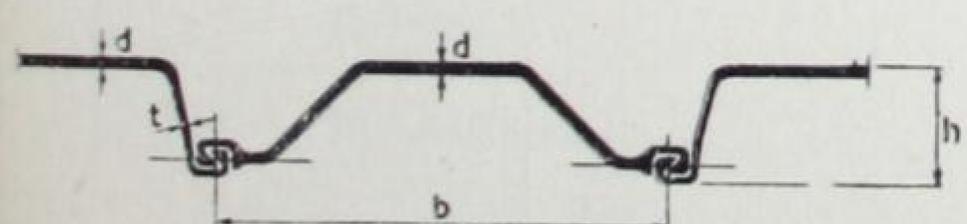
Section OGB



Sections IC IGB. IU. 2 3. 4B and 5.



Section 10A



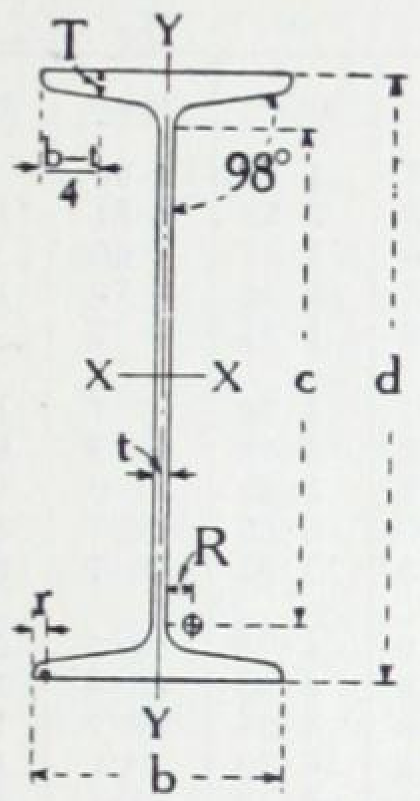
Section 2/10A

Sections IU and 10A are designed for cases where the loads are low and maximum durability is desired. They therefore have a uniform thickness of metal throughout. Section 2/10A gives a narrow wall suitable for trenches and excavations, and can be driven very close to existing structures.

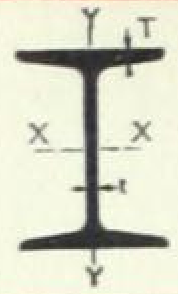
Rolling margins: + 4% and − $2\frac{1}{2}$% except section O.G.B., for which + $7\frac{1}{2}$% and − $2\frac{1}{2}$% is claimed.

The usual cutting margin is 3" over and 2" under.

ROLLED STEEL JOISTS.



PRINTED ELSEWHERE.



BRITISH STANDARD JOISTS.

PROPERTIES.

For Stanchion Properties, see page 176. Key Drawing, page 171.

Size.	Weight per Foot.	Delivery.	Web.	Flange.	Nett Depth of Web.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.		Code Word.
d × b			t	T	c	A	I_x	I_y	Z_x	Z_y	g_x	g_y	
Ins.	Lb.		Ins.	Ins.	Ins.	Ins.[2]	Ins.[4]	Ins.[4]	Ins.[3]	Ins.[3]	Ins.	Ins.	
3 × 1½	4	b*	·16	·249	1·97	1·18	1·66	·13	1·11	·17	1·19	·33	ACORN
3 × 3	8½	a*	·20	·332	1·50	2·52	3·81	1·25	2·54	·83	1·23	·70	ACRID
4 × 1¾	5	a*	·17	·239	2·94	1·47	3·66	·19	1·83	·21	1·58	·36	ADAGE
4 × 3	10	a[1]	·24	·347	2·47	2·94	7·79	1·33	3·89	·88	1·63	·67	ADIEU
4¾ × 1¾	6½	b*	·18	·325	3·52	1·91	6·73	·26	2·83	·30	1·88	·37	ADULT
5 × 3	11	a*	·22	·376	3·41	3·26	13·7	1·45	5·47	·97	2·05	·67	AEGIS
5 × 4½	20	a[2]	·29	·513	2·83	5·88	25·0	6·59	10·0	2·93	2·06	1·06	AFIRE
6 × 3	12	a*	·23	·377	4·41	3·53	21·0	1·46	7·00	·97	2·44	·64	AGAPE
6 × 4½	20	a*	·37	·431	4·00	5·89	34·7	5·40	11·6	2·40	2·43	·96	AGILE
6 × 5	25	a*	·41	·520	3·72	7·37	43·7	9·10	14·6	3·64	2·44	1·11	AGONY
7 × 4	16	a*	·25	·387	5·18	4·75	39·5	3·37	11·3	1·69	2·89	·84	AIRER
8 × 4	18	a*	·28	·398	6·16	5·30	55·6	3·51	13·9	1·75	3·24	·81	AISLE
8 × 5	28	a*	·35	·575	5·60	8·28	89·7	10·2	22·4	4·08	3·29	1·11	ALDER
8 × 6	35	a*	·35	·648	5·25	10·30	115	19·5	28·8	6·51	3·34	1·38	ALLAH
9 × 4	21	a*	·30	·457	7·04	6·18	81·1	4·15	18·0	2·07	3·62	·82	AMASS
9 × 7	50	a*	·40	·825	5·69	14·71	208	40·2	46·2	11·5	3·76	1·65	AMITY
10 × 4½	25	a*	·30	·505	7·84	7·35	122	6·49	24·5	2·88	4·08	·94	AMUSE
10 × 5	30	a*	·36	·552	7·65	8·85	146	9·73	29·2	3·89	4·06	1·05	ANENT
10 × 6	40	a*	·36	·709	7·13	11·77	205	21·8	41·0	7·25	4·17	1·36	ANKLE
10 × 8	55	a*	·40	·783	6·56	16·18	289	54·7	57·7	13·7	4·22	1·84	ANODE
10 × 8	70		·60	·970	6·33	20·58	345·04	71·67	69·0	17·9	4·09	1·87	
12 × 5	32	a[3]	·35	·550	9·65	9·45	221	9·69	36·8	3·88	4·84	1·01	AORTA
12 × 6	44	a*	·40	·717	9·11	13·00	317	22·1	52·8	7·37	4·94	1·30	APHIS
12 × 6	54	a*	·50	·883	8·79	15·89	376	28·3	62·6	9·43	4·86	1·33	APPLE
12 × 8	65	a*	·43	·904	8·32	19·12	488	65·2	81·3	16·3	5·05	1·85	APRON
13 × 5	35	a*	·35	·604	10·54	10·30	284	10·8	43·6	4·33	5·25	1·03	ARBOR
14 × 6	46	b*	·40	·698	11·15	13·59	443	21·4	63·2	7·15	5·71	1·26	ARECA
14 × 6	57	b*	·50	·873	10·81	16·78	533	27·9	76·2	9·31	5·64	1·29	ARETE
14 × 8	70	b	·46	·920	10·29	20·59	706	66·7	101	16·7	5·85	1·80	ARGOL
15 × 5	42	b*	·42	·647	12·46	12·36	428	11·8	57·1	4·72	5·89	·98	ARIAN
15 × 6	45	a*	·38	·655	12·23	13·24	492	19·9	65·6	6·62	6·10	1·23	ARROW
16 × 6	50	a*	·40	·726	13·09	14·71	618	22·5	77·3	7·49	6·48	1·24	ARTLY
16 × 6	62	b*	·55	·847	12·86	18·21	725	27·1	90·6	9·05	6·31	1·22	ASHEN
16 × 8	75	b*	·48	·938	12·26	22·06	974	68·3	122	17·1	6·64	1·76	ASTER
18 × 6	55	a*	·42	·757	15·03	16·18	842	23·6	93·5	7·88	7·21	1·21	ATAXY
18 × 7	75	a*	·55	·928	14·49	22·09	1151	46·6	128	13·3	7·22	1·45	ATLAS
18 × 8	80	b	·50	·950	14·23	23·53	1292	69·4	144	17·4	7·41	1·72	ATONE
20 × 6½	65	a*	·45	·820	16·80	19·12	1226	32·6	123	10·0	8·01	1·31	AUGHT
20 × 7½	89	a*	·60	1·01	16·23	26·19	1673	62·5	167	16·7	7·99	1·55	AVIAN
22 × 7	75	a*	·50	·834	18·68	22·06	1677	41·1	152	11·7	8·72	1·36	AWAKE
24 × 7½	95	a*	·57	1·01	20·22	27·94	2533	62·5	211	16·7	9·52	1·50	AXIOM

SIZES. The above are the British Standard sizes, 1932. They have a flange taper of 14%, *i.e.* 1 in 7 approx.

DELIVERY.
- * = Common stock size.
- *a* = Frequently rolled.
- *b* = Less frequently rolled.
- [1] = Commonly stocked at 9·5 lb.
- [2] = ,, ,, ,, 18 ,,
- [3] = ,, ,, ,, 30 ,,

EXTRAS. See page 290. Fillet Radii. See page 216.

BRITISH STANDARD JOISTS.

METRIC UNITS.

Size.		Weight per Metre.	Delivery.	Web.	Flange.	Nett Depth of Web.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
d × b				t	T	c	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Mm.	Kg.		Mm.	Mm.	Mm.	Cm.²	Cm.⁴	Cm.⁴	Cm.³	Cm.³	Cm.	Cm.
3×1½	76·2×38·1	5·95	b^*	4·1	6·3	50·1	7·59	69·1	5·20	18·1	2·74	3·02	·83
3×3	76·2×76·2	12·65	a^*	5·1	8·4	38·0	16·3	159	52·0	41·6	13·6	3·13	1·78
4×1¾	101·6×44·4	7·44	a^*	4·3	6·1	74·7	9·48	152	7·74	30·0	3·49	4·01	·90
4×3	101·6×76·2	14·88	a^1	6·1	8·8	62·7	19·0	324	55·2	63·8	14·5	4·13	1·71
4¾×1¾	120·6×44·4	9·67	b^*	4·6	8·3	89·4	12·3	280	10·9	46·4	4·92	4·78	·94
5×3	127·0×76·2	16·38	a^*	5·6	9·6	86·6	21·0	569	60·4	89·6	16·0	5·21	1·71
5×4½	127·0×114·3	29·76	a^2	7·4	13·0	71·8	37·9	1042	274	164	48·0	5·24	2·69
6×3	152·4×76·2	17·86	a^*	5·8	9·6	112	22·8	874	60·8	115	16·0	6·19	1·63
6×4½	152·4×114·3	29·76	a^*	9·4	10·9	101	38·0	1445	225	190	39·4	6·16	2·44
6×5	152·4×127·0	37·20	a^*	10·4	13·2	94·4	47·5	1819	379	239	59·7	6·19	2·83
7×4	177·8×101·6	23·82	a^*	6·3	9·8	132	30·6	1645	140	185	27·7	7·34	2·13
8×4	203·2×101·6	26·79	a^*	7·1	10·1	156	34·2	2315	146	228	28·7	8·23	2·07
8×5	203·2×127·0	41·70	a^*	8·9	14·6	142	53·4	3733	424	367	66·9	8·36	2·83
8×6	203·2×152·4	52·09	a^*	8·9	16·5	133	66·4	4789	813	471	107	8·49	3·50
9×4	228·6×101·6	31·25	a^*	7·6	11·6	179	39·8	3377	173	295	34·0	9·21	2·08
9×7	228·6×177·8	74·41	a^*	10·2	21·0	144	94·9	8663	1672	758	188	9·55	4·20
10×4½	254·0×114·3	37·20	a^*	7·6	12·8	199	47·4	5092	270	401	47·2	10·4	2·39
10×5	254·0×127·0	44·64	a^*	9·1	14·0	194	57·1	6087	405	479	63·7	10·3	2·67
10×6	254·0×152·4	59·53	a^*	9·1	18·0	181	75·9	8525	906	671	119	10·6	3·45
10×8	254·0×203·2	81·85	a^*	10·2	19·9	167	104	12016	2279	946	224	10·7	4·67
12×5	304·8×127·0	47·61	a^3	8·9	14·0	245	61·0	9202	403	604	63·6	12·3	2·57
12×6	304·8×152·4	65·51	a^*	10·2	18·2	231	83·9	13185	921	865	121	12·5	3·30
12×6	304·8×152·4	80·35	a^*	12·7	22·4	223	103	15641	1177	1026	154	12·4	3·39
12×8	304·8×203·2	96·73	a^*	10·9	23·0	211	123	20302	2713	1332	267	12·8	4·69
13×5	330·2×127·0	52·09	a^*	8·9	15·3	268	66·4	11800	450	715	70·9	13·3	2·60
14×6	355·6×152·4	68·47	b^*	10·2	17·7	283	87·7	18421	893	1036	117	14·5	3·21
14×6	355·6×152·4	84·83	b^*	12·7	22·2	274	108	22199	1163	1249	153	14·3	3·28
14×8	355·6×203·2	104·2	b	11·7	23·4	261	133	29368	2775	1652	273	14·9	4·57
15×5	381·0×127·0	62·49	b^*	10·7	16·4	317	79·7	17823	492	936	77·3	15·0	2·50
15×6	381·0×152·4	66·97	a^*	9·6	16·6	311	85·4	20475	827	1075	108	15·5	3·11
16×6	406·4×152·4	74·41	a^*	10·2	18·4	333	94·9	25727	935	1266	123	16·5	3·14
16×6	406·4×152·4	92·23	b^*	14·0	21·5	327	117	30179	1130	1485	148	16·0	3·10
16×8	406·4×203·2	111·6	b^*	12·2	23·8	311	142	40537	2843	1995	280	16·9	4·47
18×6	457·2×152·4	81·85	a^*	10·7	19·2	382	104	35036	984	1533	129	18·3	3·07
18×7	457·2×177·8	111·7	a^*	14·0	23·6	368	143	47916	1938	2096	218	18·3	3·69
18×8	457·2×203·2	119·1	b	12·7	24·1	362	152	53780	2890	2353	284	18·8	4·36
20×6½	508·0×165·1	96·73	a^*	11·4	20·8	427	123	51037	1355	2009	164	20·3	3·31
20×7½	508·0×190·5	132·4	a^*	15·2	25·7	412	169	69629	2603	2741	273	20·3	3·93
22×7	558·8×177·8	111·6	a^*	12·7	21·2	474	142	69793	1709	2498	192	22·1	3·46
24×7½	609·6×190·5	141·4	a^*	14·5	25·7	514	180	105433	2603	3459	273	24·2	3·81

The symbols in the column headed "Delivery" indicate the time required for delivery, and are explained on page 172. For Code Words, see page 172; for Extras, see page 290.

BRITISH STANDARD JOISTS, AS GIRDERS.

SAFE DISTRIBUTED LOADS, 8 TONS STRESS.

Size. d × b	Weight per Foot.	Resistance Moment.	Max. Distributed Load.	SAFE LOADS IN TONS. 6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′	30′	32′	36′	40′
Ins.	Lb.	In.-Tns.	Tons.																
3 × 1½	4	8·88	3·8	·99	·74	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3 × 3	8½	20·3	4·8	2·3	1·7	1·4	...	...	...	...	...	...	...	...	...	...	...	...	...
4 × 1¾	5	14·6	5·4	1·6	1·2	·98	·81	...	...	...	...	...	...	...	...	...	...	...	...
4 × 3	10	31·1	7·7	3·5	2·6	2·1	1·7	...	...	...	...	...	...	...	...	...	...	...	...
4¾ × 1¾	6½	22·6	6·8	2·5	1·9	1·5	1·3	1·1	·94	...	...	...	...	...	...	...	...	...	...
5 × 3	11	43·8	8·8	4·9	3·6	2·9	2·4	2·1	1·8	...	...	...	...	...	...	...	...	...	...
5 × 4½	20	80·1	11·6	8·9	6·7	5·3	4·4	3·8	...	...	...	...	...	...	...	...	...	...	...
6 × 3	12	56·0	11·0	6·2	4·7	3·7	3·1	2·7	2·3	2·1	...	...	...	...	...	...	...	...	...
6 × 4½	20	92·6	17·8	10	7·7	6·2	5·1	4·4	3·9	3·4	3·1	...	...	...	...	...	...	...	...
6 × 5	25	116	19·7	13	9·7	7·8	6·5	5·5	4·9	4·3	3·9	...	...	...	...	...	...	...	...
7 × 4	16	90·3	14·0	10	7·5	6·0	5·0	4·3	3·8	3·3	3·0	2·7	2·5	...	...	...	...	...	...
8 × 4	18	111	17·9	12	9·3	7·4	6·2	5·3	4·6	4·1	3·7	3·4	3·1	...	...	...	...	...	...
8 × 5	28	179	22·4	20	15	12	10	8·5	7·5	6·6	6·0	5·4	5·0	4·6	...	...	...	...	...
8 × 6	35	230	22·4	...	19	15	13	11	9·6	8·5	7·7	7·0	6·4	...	...	...	...	...	...
9 × 4	21	144	21·6	16	12	9·6	8·0	6·9	6·0	5·3	4·8	4·4	4·0	3·7	3·4	...	...	...	...
9 × 7	50	370	28·8	...	...	25	21	18	15	14	12	11	10	9·5	8·8	...	...	...	...
10 × 4½	25	196	24·0	22	16	13	11	9·3	8·2	7·3	6·5	5·9	5·4	5·0	4·7	4·4	4·1	3·6	3·3
10 × 5	30	234	28·8	26	19	16	13	11	9·7	8·7	7·8	7·1	6·5	6·0	5·6	5·2	4·9	...	...
10 × 6	40	328	28·8	...	27	22	18	16	14	12	11	10	9·1	8·4	7·8	7·3	...	...	...
10 × 8	55	462	32·0	...	...	31	26	22	19	17	15	14	13	12	11	10	9·6	8·6	...
12 × 5	32	295	33·6	33	25	20	16	14	12	11	9·8	8·9	8·2	7·6	7·0	6·5	6·1	5·5	...
12 × 6	44	422	38·4	...	35	28	23	20	18	16	14	13	12	11	10	9·4	8·8	7·8	7·0
12 × 6	54	501	48·0	...	42	33	28	24	21	19	17	15	14	13	12	11	10	9·3	8·4
12 × 8	65	650	41·3	...	...	...	36	31	27	24	22	20	18	17	15	14	14	12	...
13 × 5	35	349	36·4	...	29	23	19	17	15	13	12	11	10	8·9	8·3	7·8	7·3	...	...
14 × 6	46	506	44·8	...	42	34	28	24	21	19	17	15	14	13	12	11	11	9·4	8·4
14 × 6	57	610	56·0	...	51	41	34	29	25	23	20	18	17	16	15	14	13	11	10
14 × 8	70	806	51·5	...	...	...	45	38	34	30	27	24	22	21	19	18	17	15	13
15 × 5	42	457	50·4	...	38	30	25	22	19	17	15	14	13	12	11	10	9·5	8·5	7·6
15 × 6	45	525	45·6	...	44	35	29	25	22	19	17	16	15	13	12	12	11	9·7	8·7
16 × 6	50	618	51·2	...	...	41	34	29	26	23	21	19	17	16	15	14	13	11	10
16 × 6	62	725	70·4	...	60	48	40	35	30	27	24	22	20	19	17	16	15	13	12
16 × 8	75	974	61·4	...	...	...	54	46	41	36	32	30	27	25	23	22	20	18	16
18 × 6	55	748	60·5	...	...	50	42	36	31	28	25	23	21	19	18	17	16	14	12
18 × 7	75	1023	79·2	...	...	68	57	49	43	38	34	31	28	26	24	23	21	19	17
18 × 8	80	1148	72·0	...	...	...	64	55	48	43	38	35	32	29	27	26	24	21	19
20 × 6½	65	981	72·0	...	...	65	54	47	41	36	33	30	27	25	23	22	20	18	16
20 × 7½	89	1338	96·0	...	...	89	74	64	56	50	45	41	37	34	32	30	28	25	22
22 × 7	75	1220	88·0	...	...	81	68	58	51	45	41	37	34	31	29	27	25	23	20
24 × 7½	95	1689	109	...	...	...	94	80	70	63	56	51	47	43	40	38	35	31	28

SAFE LOADS. The safe loads, which include the weights of the joists, are based on a working stress of 8 tons per square inch; ends freely supported.

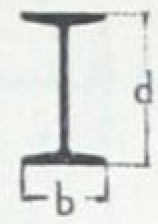
RESISTANCE MOMENT. The tabulated figures = $Z_x \times 8$.

MAXIMUM DISTRIBUTED LOADS. These equal 8 × depth (d) × web thickness (t) and correspond to a maximum shear stress of 4½ tons per square inch, approx. This is well within B.S.S. 449, § 10.

DEFLECTION. Spans to the right of the zig-zag line exceed 24 times the depth. For London buildings this ratio must not be exceeded unless the stress is reduced to keep the calculated deflection within 1/325th of the span.

BRITISH STANDARD JOISTS.

SAFE STRESSES IN WEBS.



Size. d × b	Weight per Foot.	Ratio of Fillet Stress to Extreme Fibre Stress.	Web Thickness. t	Web Area. d × t	Vertical Shear Divisors giving Stress at Centre.	Vertical Shear Divisors giving Stress at Fillet.	Safe Principal Compressive Stress. P	Safe Column Stress on Web; and Load per 1″ run. P_1	$P_1 \times t$
Ins.	Lb.		Ins.	Ins.[2]					
3 × 1½	4	·657	·16	·48	·42	·47	5·85	5·70	·91
3 × 3	8½	·499	·20	·60	·52	·54	5·94	5·89	1·18
4 × 1¾	5	·735	·17	·68	·59	·72	5·71	5·40	·92
4 × 3	10	·617	·24	·96	·84	·91	5·89	5·78	1·39
4¾ × 1¾	6½	·741	·18	·85	·75	·90	5·61	5·22	·94
5 × 3	11	·682	·22	1·10	·97	1·09	5·76	5·52	1·22
5 × 4½	20	·566	·29	1·45	1·26	1·33	5·90	5·81	1·68
6 × 3	12	·735	·23	1·38	1·22	1·41	5·63	5·25	1·21
6 × 4½	20	·666	·37	2·22	1·94	2·18	5·89	5·77	2·13
6 × 5	25	·619	·41	2·46	2·14	2·34	5·92	5·83	2·39
7 × 4	16	·740	·25	1·75	1·55	1·81	5·57	5·12	1·28
8 × 4	18	·770	·28	2·24	1·98	2·38	5·51	5·02	1·41
8 × 5	28	·700	·35	2·80	2·46	2·78	5·75	5·48	1·92
8 × 6	35	·656	·35	2·80	2·48	2·68	5·77	5·55	1·94
9 × 4	21	·783	·30	2·70	2·37	2·90	5·44	4·88	1·46
9 × 7	50	·632	·40	3·60	3·16	3·37	5·79	5·59	2·24
10 × 4½	25	·785	·30	3·00	2·66	3·19	5·31	4·62	1·39
10 × 5	30	·765	·36	3·60	3·17	3·79	5·55	5·08	1·83
10 × 6	40	·713	·36	3·60	3·19	3·54	5·60	5·20	1·87
10 × 8	55	·656	·40	4·00	3·56	3·81	5·74	5·45	2·18
12 × 5	32	·804	·35	4·20	3·68	4·60	5·23	4·47	1·56
12 × 6	44	·759	·40	4·80	4·23	4·95	5·47	4·94	1·98
12 × 6	54	·732	·50	6·00	5·21	6·02	5·69	5·37	2·68
12 × 8	65	·693	·43	5·16	4·59	5·00	5·62	5·24	2·25
13 × 5	35	·808	·35	4·55	4·01	4·97	5·08	4·22	1·48
14 × 6	46	·796	·40	5·60	4·92	6·00	5·20	4·43	1·77
14 × 6	57	·772	·50	7·00	6·09	7·31	5·53	5·04	2·52
14 × 8	70	·736	·46	6·44	5·73	6·43	5·49	4·98	2·29
15 × 5	42	·831	·42	6·30	5·46	7·26	5·10	4·25	1·78
15 × 6	45	·813	·38	5·70	5·04	6·23	4·96	3·99	1·52
16 × 6	50	·819	·40	6·40	5·63	7·01	4·92	3·93	1·57
16 × 6	62	·804	·55	8·80	7·61	9·69	5·45	4·89	2·69
16 × 8	75	·769	·48	7·68	6·83	7·87	5·33	4·67	2·24
18 × 6	55	·833	·42	7·56	6·62	8·50	4·70	3·62	1·52
18 × 7	75	·805	·55	9·90	8·61	10·7	5·30	4·61	2·54
18 × 8	80	·789	·50	9·00	7·98	9·45	5·18	4·39	2·19
20 × 6½	65	·840	·45	9·00	7·87	10·2	4·60	3·45	1·55
20 × 7½	89	·811	·60	12·0	10·4	13·1	5·25	4·53	2·72
22 × 7	75	·850	·50	11·0	9·57	12·7	4·59	3·44	1·72
24 × 7½	95	·843	·57	13·7	11·6	15·6	4·73	3·64	2·07

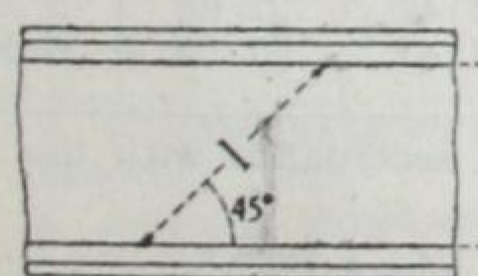


Fig. 1.

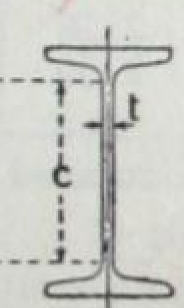


Fig. 2.

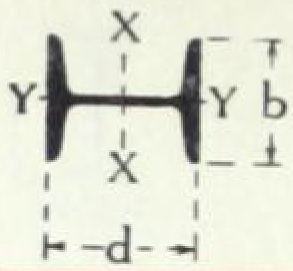
The above special properties are used in investigating the effect of heavy concentrated loads, as explained on pages 60 to 62.

P is the safe stress (tons per square inch) by Fidler's formula for a strut with fixed ends of length equal to $^1/_2\ l$ (Fig. 1).

P_1 is by the same formula for a strut of length c (Fig. 2).

$P_1 \times t$ is the safe buckling load on web in tons per lineal inch of web.

N.B.—With loads involving impact or vibration, reduce the loads and stresses above by 50%.



BRITISH STANDARD JOISTS.

STANCHION PROPERTIES.

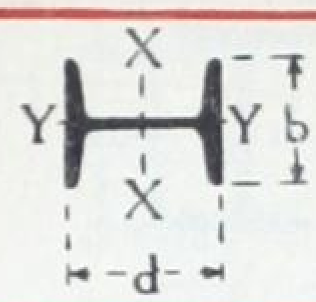
Size.	Weight per Foot.	Radii of Gyration.		Bending Moment Multipliers.		Eccentric Load Multipliers.		Area.	$\frac{12}{g_y}$
d × b		g_x	g_y	Flange.	Web.	Flange.	Web.	A	
Ins.	Lb.	Ins.	Ins.					Ins.^2	
3 × 1½	4	1·19	·33	1·06	7·06	2·59	1·56	1·18	36·8
3 × 3	8½	1·23	·70	·99	3·06	2·49	1·31	2·52	17·1
4 × 1¾	5	1·58	·36	·80	6·90	2·60	1·59	1·47	33·7
4 × 3	10	1·63	·67	·76	3·32	2·51	1·40	2·94	17·9
4¾ × 1¾	6½	1·88	·37	·67	6·39	2·60	1·58	1·91	32·4
5 × 3	11	2·05	·67	·59	3·34	2·49	1·37	3·26	17·9
5 × 4½	20	2·06	1·06	·59	2·00	2·47	1·29	5·88	11·3
6 × 3	12	2·44	·64	·51	3·63	2·51	1·42	3·53	18·7
6 × 4½	20	2·43	·96	·51	2·44	2·52	1·45	5·89	12·5
6 × 5	25	2·44	1·11	·50	2·03	2·51	1·42	7·37	10·8
7 × 4	16	2·89	·84	·42	2·83	2·47	1·35	4·75	14·3
8 × 4	18	3·24	·81	·38	3·02	2·52	1·42	5·30	14·7
8 × 5	28	3·29	1·11	·37	2·03	2·48	1·36	8·28	10·8
8 × 6	35	3·34	1·38	·36	1·58	2·43	1·28	10·30	8·70
9 × 4	21	3·62	·82	·34	2·97	2·55	1·45	6·18	14·6
9 × 7	50	3·76	1·65	·32	1·29	2·43	1·26	14·71	7·27
10 × 4½	25	4·08	·94	·30	2·55	2·50	1·38	7·35	12·8
10 × 5	30	4·06	1·05	·30	2·27	2·52	1·41	8·85	11·4
10 × 6	40	4·17	1·36	·29	1·62	2·44	1·29	11·77	8·82
10 × 8	55	4·22	1·84	·28	1·18	2·40	1·24	16·18	6·52
12 × 5	32	4·84	1·01	·26	2·45	2·54	1·43	9·45	11·9
12 × 6	44	4·94	1·30	·25	1·78	2·48	1·36	13·00	9·23
12 × 6	54	4·86	1·33	·25	1·70	2·52	1·42	15·89	9·02
12 × 8	65	5·05	1·85	·24	1·17	2·41	1·25	19·12	6·49
13 × 5	35	5·25	1·03	·24	2·40	2·53	1·42	10·30	11·8
14 × 6	46	5·71	1·26	·21	1·89	2·53	1·38	13·59	9·52
14 × 6	57	5·64	1·29	·22	1·80	2·54	1·45	16·78	9·30
14 × 8	70	5·85	1·80	·20	1·23	2·43	1·28	20·59	6·67
15 × 5	42	5·89	·98	·22	2·60	2·62	1·55	12·36	12·2
15 × 6	45	6·10	1·23	·20	2·02	2·51	1·38	13·24	9·84
16 × 6	50	6·48	1·24	·19	1·95	2·52	1·39	14·71	9·68
16 × 6	62	6·31	1·22	·21	2·02	2·61	1·55	18·21	9·84
16 × 8	75	6·64	1·76	·18	1·29	2·45	1·31	22·06	6·82
18 × 6	55	7·21	1·21	·17	2·05	2·56	1·43	16·18	9·92
18 × 7	75	7·22	1·45	·17	1·66	2·55	1·45	22·09	8·28
18 × 8	80	7·41	1·72	·17	1·35	2·48	1·34	23·53	6·98
20 × 6½	65	8·01	1·31	·16	1·92	2·56	1·43	19·12	9·23
20 × 7½	89	7·99	1·55	·16	1·56	2·57	1·47	26·19	7·74
22 × 7	75	8·72	1·36	·14	1·89	2·59	1·47	22·06	8·82
24 × 7½	95	9·52	1·50	·13	1·67	2·59	1·47	27·94	8·00

1. **STRESSES AND SAFE LOADS.** The tabulated loads are calculated in accordance with the B.S.S. No. 449, § 15 (b). For the stresses, see page 95.

2. **END FIXING.** The tabulated loads apply to pillars of one storey "where both ends are held in position but unrestrained in direction." For other cases, see page 94.

B.S. JOISTS AS STANCHIONS.

SAFE CENTRAL LOADS, BY BRITISH STANDARD FORMULA.

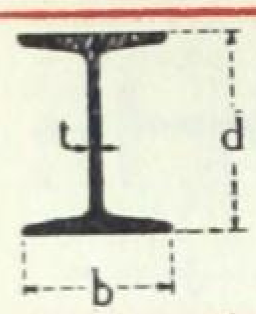


Size. d × b	Weight per Foot.	SAFE LOADS IN TONS. 5′	6′	7′	8′	9′	10′	11′	12′	14′	16′	18′	20′	22′
Ins.	Lb.													
3 × 1½	4	1·7	...	...	...	...	...	...	...	...	...	...	...	...
3 × 3	8½	11	9·2	7·3	6·0	4·8	4·0	3·4	...	...	...	...	...	...
4 × 1¾	5	2·4	...	...	...	...	...	...	...	...	...	...	...	...
4 × 3	10	13	10	8·1	6·5	5·3	4·4	3·6	...	...	...	...	...	...
4¾ × 1¾	6½	3·4	2·4	...	...	...	...	...	...	...	...	...	...	...
5 × 3	11	14	11	8·9	7·2	5·8	4·9	4·0	...	...	...	...	...	...
5 × 4½	20	35	32	29	25	22	19	16	14	11	8·6	...	...	...
6 × 3	12	15	11	9·1	7·1	5·8	4·8	...	...	...	...	...	...	...
6 × 4½	20	34	30	26	22	19	16	14	12	9·1	...	...	...	...
6 × 5	25	45	42	38	33	29	25	22	19	15	12	9·2	...	...
7 × 4	16	25	22	18	15	13	11	8·8	7·6	5·7	...	...	...	...
8 × 4	18	28	23	19	16	13	11	9·3	8·1	...	...	...	...	...
8 × 5	28	51	47	42	37	33	28	24	22	16	13	10	...	...
8 × 6	35	67	64	60	56	51	46	41	37	29	24	19	16	13
9 × 4	21	32	27	23	19	16	13	11	9·5	...	...	...	...	...
9 × 7	50	99	95	92	88	83	78	72	66	55	45	38	31	26
10 × 4½	25	42	37	32	27	23	20	17	14	11	...	...	...	...
10 × 5	30	53	48	43	37	32	28	24	21	16	13	...	...	...
10 × 6	40	76	73	68	63	58	52	46	41	33	27	21	18	15
10 × 8	55	110	107	104	100	96	91	86	81	68	58	49	42	35
12 × 5	32	56	50	45	38	33	28	24	21	16	12	...	...	...
12 × 6	44	83	79	74	68	61	54	48	43	34	27	22	18	...
12 × 6	54	102	98	91	84	77	68	61	54	43	34	28	24	19
12 × 8	65	130	127	123	119	114	108	102	96	81	69	58	50	42
13 × 5	35	61	56	49	42	36	31	27	24	18	14	...	...	...
14 × 6	46	87	82	76	69	62	55	48	43	34	27	22	18	...
14 × 6	57	107	102	95	87	79	70	62	54	43	34	28	23	...
14 × 8	70	140	136	132	127	121	114	108	101	85	71	60	51	43
15 × 5	42	72	65	56	48	41	35	31	26	20	15	...	...	...
15 × 6	45	84	79	72	66	58	52	45	40	32	25	20	16	...
16 × 6	50	93	88	81	74	66	58	51	45	36	28	23	19	...
16 × 6	62	116	108	99	90	80	71	62	54	43	34	28	22	...
16 × 8	75	150	145	141	135	129	121	114	106	89	74	62	53	44
18 × 6	55	102	96	88	80	70	62	54	48	38	29	24	20	...
18 × 7	75	145	139	132	123	114	104	94	85	68	56	45	37	32
18 × 8	80	159	154	149	143	135	127	119	110	92	76	64	54	45
20 × 6½	65	123	116	109	100	90	80	72	63	50	40	32	27	...
20 × 7½	89	174	168	161	152	142	132	120	109	89	73	61	50	42
22 × 7	75	143	137	128	119	109	98	87	78	62	50	40	34	28
24 × 7½	95	184	178	169	159	148	137	123	112	90	74	61	50	43

3. SLENDERNESS RATIO. To find the l/g_y of any section, multiply the tabulated $12/g_y$ by the height in feet.

4. BENDING MOMENT. The Bending Moment and Eccentric Load multipliers are explained on pages 96, 100.

5. ZIG-ZAG LINE. Heights to the right of the zig-zag line exceed 150 g_y, and by the B.S.S. 449 may only be used for subsidiary members in compression.



AMERICAN STANDARD JOISTS.

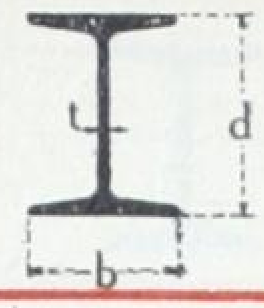
PROPERTIES.

Size.		Weight per Foot.	Web Thickness.	Flange Thickness.		Radii of Fillet.		Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
d	b		t	T max.	T min.	R	r	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
3	2·330	5·7	·170	·350	·170	·27	·10	1·64	2·5	·46	1·7	·40	1·23	·53
,,	2·411	6·5	·251	,,	,,	,,	,,	1·88	2·7	·51	1·8	·43	1·19	·52
,,	2·509	7·5	·349	,,	,,	,,	,,	2·17	2·9	·59	1·9	·47	1·15	·52
4	2·660	7·7	·190	·396	·190	·29	·11	2·21	6·0	·77	3·0	·58	1·64	·59
,,	2·723	8·5	·253	,,	,,	,,	,,	2·46	6·3	·83	3·2	·61	1·60	·58
,,	2·796	9·5	·326	,,	,,	,,	,,	2·76	6·7	·91	3·3	·65	1·56	·58
,,	2·870	10·5	·400	,,	,,	,,	,,	3·05	7·1	1·0	3·5	·70	1·52	·57
5	3·000	10·0	·210	·443	·210	·31	·13	2·87	12·1	1·2	4·8	·82	2·05	·65
,,	3·137	12·25	·347	,,	,,	,,	,,	3·56	13·5	1·4	5·4	·91	1·95	·63
,,	3·284	14·75	·494	,,	,,	,,	,,	4·29	15·0	1·7	6·0	1·0	1·87	·63
6	3·330	12·5	·230	·488	·230	·33	·14	3·61	21·8	1·8	7·3	1·1	2·46	·72
,,	3·443	14·75	·343	,,	,,	,,	,,	4·29	23·8	2·1	7·9	1·2	2·36	·69
,,	3·565	17·25	·465	,,	,,	,,	,,	5·02	26·0	2·3	8·7	1·3	2·28	·68
7	3·660	15·3	·250	·534	·250	·35	·15	4·43	36·2	2·7	10·4	1·5	2·86	·78
,,	3·755	17·5	·345	,,	,,	,,	,,	5·09	38·9	2·9	11·1	1·6	2·77	·76
,,	3·860	20·0	·450	,,	,,	,,	,,	5·83	41·9	3·1	12·0	1·6	2·68	·74
8	4·000	18·4	·270	·581	·270	·37	·16	5·34	56·9	3·8	14·2	1·9	3·26	·84
,,	4·079	20·5	·349	,,	,,	,,	,,	5·97	60·2	4·0	15·1	2·0	3·18	·82
,,	4·171	23·0	·441	,,	,,	,,	,,	6·71	64·2	4·4	16·0	2·1	3·09	·81
,,	4·262	25·5	·532	,,	,,	,,	,,	7·43	68·1	4·7	17·0	2·2	3·03	·80
9	4·330	21·8	·290	·627	·290	·39	·17	6·32	84·9	5·2	18·9	2·4	3·67	·90
,,	4·437	25·0	·397	,,	,,	,,	,,	7·28	91·4	5·6	20·3	2·5	3·54	·88
,,	4·601	30·0	·561	,,	,,	,,	,,	8·76	101	6·4	22·5	2·8	3·40	·85
,,	4·764	35·0	·724	,,	,,	,,	,,	10·22	111	7·3	24·7	3·0	3·30	·84
10	4·660	25·4	·310	·673	·310	·41	·19	7·38	122	6·9	24·4	3·0	4·07	·97
,,	4·797	30·0	·447	,,	,,	,,	,,	8·75	133	7·6	26·7	3·2	3·91	·93
,,	4·944	35·0	·594	,,	,,	,,	,,	10·22	146	8·5	29·2	3·4	3·78	·91
,,	5·091	40·0	·741	,,	,,	,,	,,	11·69	158	9·4	31·6	3·7	3·68	·90
12	5·000	31·8	·350	·738	·350	·45	·21	9·26	216	9·5	36·0	3·8	4·83	1·01
,,	5·078	35·0	·428	,,	,,	,,	,,	10·20	227	10·0	37·8	3·9	4·72	·99
12	5·250	40·8	·460	·859	·460	·56	·28	11·84	269	13·8	44·8	5·3	4·77	1·08
,,	5·355	45·0	·565	,,	,,	,,	,,	13·10	284	14·8	47·3	5·5	4·66	1·06
,,	5·477	50·0	·687	,,	,,	,,	,,	14·57	302	16·0	50·3	5·8	4·55	1·05
,,	5·600	55·0	·810	,,	,,	,,	,,	16·04	319	17·3	53·2	6·2	4·46	1·04
15	5·500	42·9	·410	·834	·410	·51	·25	12·49	442	14·6	58·9	5·3	5·95	1·08
,,	5·542	45·0	·452	,,	,,	,,	,,	13·12	454	15·0	60·5	5·4	5·88	1·07
,,	5·640	50·0	·550	,,	,,	,,	,,	14·59	481	16·0	64·2	5·7	5·74	1·05
,,	5·738	55·0	·648	,,	,,	,,	,,	16·06	509	17·0	67·8	5·9	5·63	1·03
15	6·000	60·8	·590	1·04	·590	·69	·35	17·68	609	26·0	81·2	8·7	5·87	1·21
,,	6·082	65·0	·672	,,	,,	,,	,,	18·91	632	27·2	84·3	8·9	5·78	1·20
,,	6·180	70·0	·770	,,	,,	,,	,,	20·38	660	28·8	87·9	9·3	5·69	1·19
,,	6·278	75·0	·868	,,	,,	,,	,,	21·85	687	30·6	91·6	9·8	5·61	1·18

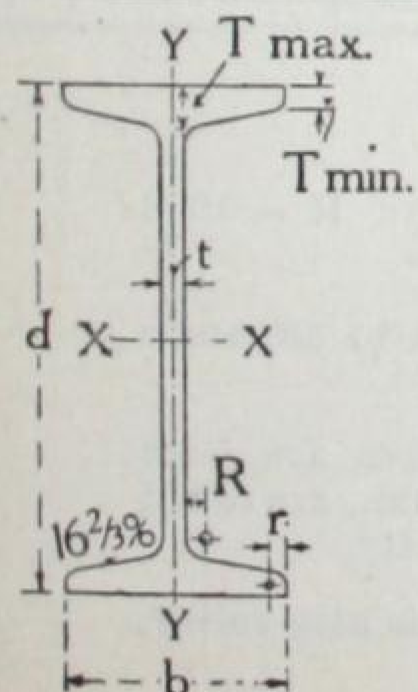
Continued on next page.

AMERICAN STANDARD JOISTS.

PROPERTIES.—Continued.



Size.		Weight per Foot.	Web Thickness.	Flange Thickness.		Radii of Fillet.		Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
d	b		t	T max.	T min.	R	r	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
15	6·400	81·3	·800	1·50	1·03	·90	·48	23·57	789	41·3	105	12·9	5·79	1·32
,,	6·472	85·0	·872	,,	,,	,,	,,	24·65	809	42·9	108	13·3	5·73	1·32
,,	6·570	90·0	·970	,,	,,	,,	,,	26·12	837	45·2	112	13·8	5·66	1·32
,,	6·668	95·0	1·07	,,	,,	,,	,,	27·59	864	47·7	115	14·3	5·60	1·31
,,	6·767	100	1·17	,,	,,	,,	,,	29·08	892	50·2	119	14·8	5·54	1·31
18	6·000	54·7	·460	·922	·460	·56	·28	15·94	795	21·2	88·4	7·1	7·07	1·15
,,	6·087	60·0	·547	,,	,,	,,	,,	17·50	838	22·3	93·1	7·3	6·92	1·13
,,	6·169	65·0	·629	,,	,,	,,	,,	18·98	878	23·4	97·5	7·6	6·80	1·11
,,	6·251	70·0	·711	,,	,,	,,	,,	20·46	917	24·5	102	7·8	6·70	1·09
18	7·000	75·6	·560	1·19	·659	·66	·34	22·04	1142	46·3	127	13·2	7·20	1·45
,,	7·072	80·0	·632	,,	,,	,,	,,	23·34	1177	47·9	131	13·6	7·10	1·43
,,	7·154	85·0	·714	,,	,,	,,	,,	24·81	1217	49·8	135	14·0	7·00	1·42
,,	7·236	90·0	·796	,,	,,	,,	,,	26·29	1256	51·9	140	14·3	6·91	1·40
20	6·250	65·4	·500	1·03	·550	·60	·30	19·08	1169	27·9	117	8·9	7·83	1·21
,,	6·317	70·0	·567	,,	,,	,,	,,	20·42	1214	28·9	121	9·2	7·71	1·19
,,	6·391	75·0	·641	,,	,,	,,	,,	21·90	1263	30·1	126	9·4	7·60	1·17
20	7·000	81·4	·600	1·18	·650	·70	·36	23·74	1466	45·8	147	13·1	7·86	1·39
,,	7·053	85·0	·653	,,	,,	,,	,,	24·80	1502	47·0	150	13·3	7·78	1·38
,,	7·126	90·0	·726	,,	,,	,,	,,	26·26	1550	48·7	155	13·7	7·68	1·36
,,	7·200	95·0	·800	,,	,,	,,	,,	27·74	1600	50·5	160	14·0	7·59	1·35
,,	7·273	100	·873	,,	,,	,,	,,	29·20	1648	52·4	165	14·4	7·51	1·34
24	7·000	79·9	·500	1·14	·600	·60	·30	23·33	2087	42·9	174	12·2	9·46	1·36
,,	7·063	85·0	·563	,,	,,	,,	,,	24·84	2160	44·2	180	12·5	9·33	1·33
,,	7·124	90·0	·624	,,	,,	,,	,,	26·30	2230	45·5	186	12·8	9·21	1·32
,,	7·186	95·0	·686	,,	,,	,,	,,	27·79	2301	47·0	192	13·0	9·08	1·30
,,	7·247	100	·747	,,	,,	,,	,,	29·25	2372	48·4	198	13·4	9·05	1·29
24	7·875	106	·625	1·40	·800	·60	·30	30·98	2811	78·9	234	20·0	9·53	1·60
,,	7·925	110	·675	,,	,,	,,	,,	32·18	2869	80·6	239	20·3	9·44	1·58
,,	7·987	115	·737	,,	,,	,,	,,	33·67	2940	82·8	245	20·7	9·35	1·57
,,	8·048	120	·798	,,	,,	,,	,,	35·13	3011	84·9	251	21·1	9·26	1·56



TAPER OF FLANGE. The 16⅔% slope corresponds to a slope of 1 in 6, or an angle of 9° 28′.

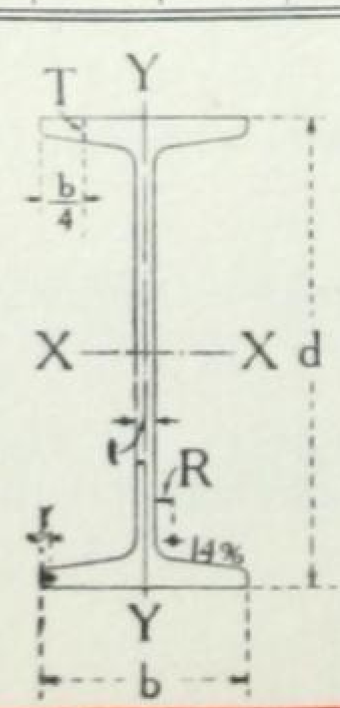
RANGE OF WEIGHTS. The first section in each group is the minimum or stock section. The other sections are produced by spacing the rolls.

DELIVERY. These sections are not readily obtainable in Europe, although a number of the larger sizes are obtainable from the Continent, in "rolling quantities" only.

METRIC JOISTS.

STANDARD CONTINENTAL SECTIONS.

METRIC UNITS.									BRITISH UNITS.					
Size.	Weight per Metre.	Thickness. Web.	Thickness. Flange.	Area.	Moments of Inertia.		Section Moduli.		Size.	Weight per Foot.	Thickness. Web.	Thickness. Flange.	Area.	Sec. Mod.
d × b		t	T	A	I_x	I_y	Z_x	Z_y	d × b		t	T	A	Z_x
Mm.	Kilos.	Mm.	Mm.	Cm.²	Cm.⁴	Cm.⁴	Cm.³	Cm.³	Ins.	Lb.	Ins.	Ins.	Ins.²	Ins.³
80 × 42	5,95	3,9	5,9	7,58	77,8	6,29	19,5	3,00	3·15 × 1·65	4·00	·154	·232	1·17	1·18
90 × 46	7,06	4,2	6,3	9,00	117	8,78	26,0	3,82	3·54 × 1·81	4·74	·165	·248	1·39	1·58
100 × 50	8,33	4,5	6,8	10,6	171	12,2	34,2	4,88	3·94 × 1·97	5·60	·177	·268	1·64	2·08
110 × 54	9,65	4,8	7,2	12,3	239	16,2	43,5	6,00	4·33 × 2·13	6·48	·189	·283	1·91	2·64
120 × 58	11,1	5,1	7,7	14,2	328	21,5	54,7	7,41	4·72 × 2·28	7·46	·201	·303	2·20	3·33
130 × 62	12,6	5,4	8,1	16,1	436	27,5	67,1	8,87	5·12 × 2·44	8·49	·213	·319	2·50	4·09
140 × 66	14,3	5,7	8,6	18,3	573	35,2	81,9	10,7	5·51 × 2·60	9·61	·224	·339	2·84	4·99
150 × 70	16,0	6,0	9,0	20,4	735	43,9	98,0	12,5	5·91 × 2·76	10·8	·236	·354	3·16	5·97
160 × 74	17,9	6,3	9,5	22,8	935	54,7	117	14,8	6·30 × 2·91	12·0	·248	·374	3·53	7·14
170 × 78	19,8	6,6	9,9	25,2	1166	66,6	137	17,1	6·69 × 3·07	13·3	·260	·390	3·91	8·36
180 × 82	21,9	6,9	10,4	27,9	1446	81,3	161	19,8	7·09 × 3·23	14·7	·272	·409	4·32	9·82
190 × 86	23,9	7,2	10,8	30,6	1763	97,4	186	22,7	7·48 × 3·39	16·1	·283	·425	4·74	11·3
200 × 90	26,2	7,5	11,3	33,5	2142	117	214	26,0	7·87 × 3·54	17·6	·295	·445	5·19	13·1
210 × 94	28,5	7,8	11,7	36,4	2563	138	244	29,4	8·27 × 3·70	19·1	·307	·461	5·64	14·9
220 × 98	31,0	8,1	12,2	39,6	3060	162	278	33,1	8·66 × 3·86	20·8	·319	·480	6·13	17·0
230 × 102	33,4	8,4	12,6	42,7	3607	189	314	37,1	9·06 × 4·02	22·4	·331	·496	6·61	19·2
240 × 106	36,2	8,7	13,1	46,1	4246	221	354	41,7	9·45 × 4·17	24·3	·343	·516	7·15	21·5
250 × 110	39,0	9,0	13,6	49,7	4966	256	397	46,5	9·84 × 4·33	26·2	·354	·535	7·70	24·2
260 × 113	41,8	9,4	14,1	53,4	5744	288	442	51,0	10·24 × 4·45	28·1	·370	·555	8·26	26·9
270 × 116	44,8	9,7	14,7	57,2	6626	326	491	56,2	10·63 × 4·57	30·1	·382	·579	8·86	30·0
280 × 119	47,9	10,1	15,2	61,1	7587	364	542	61,2	11·02 × 4·69	32·2	·398	·598	9·46	33·0
290 × 122	50,9	10,4	15,7	64,9	8636	406	596	66,6	11·42 × 4·80	34·2	·409	·618	10·0	36·2
300 × 125	54,2	10,8	16,2	69,1	9800	451	653	72,2	11·81 × 4·92	36·4	·425	·638	10·7	39·8
320 × 131	61,0	11,5	17,3	77,8	12510	555	782	84,7	12·60 × 5·16	41·0	·453	·681	12·1	47·6
340 × 137	68,1	12,2	18,3	86,8	15695	674	923	98,4	13·39 × 5·39	45·7	·480	·720	13·4	56·2
360 × 143	76,1	13,0	19,5	97,1	19605	818	1089	114	14·17 × 5·63	51·1	·512	·768	15·1	66·4
380 × 149	84,0	13,7	20,5	107	24012	975	1264	131	14·96 × 5·87	56·4	·539	·807	16·6	77·0
400 × 155	92,6	14,4	21,6	118	29213	1158	1461	149	15·75 × 6·10	62·2	·567	·850	18·3	89·0
425 × 163	104	15,3	23,0	132	36973	1437	1740	176	16·73 × 6·42	69·6	·602	·906	20·5	106
450 × 170	115	16,2	24,3	147	45852	1725	2037	203	17·72 × 6·69	77·5	·638	·957	22·8	124
475 × 178	128	17,1	25,6	163	56481	2088	2378	235	18·70 × 7·01	86·0	·673	1·01	25·3	145
500 × 185	141	18,0	27,0	180	68738	2478	2750	268	19·69 × 7·28	94·4	·709	1·06	27·7	168
550 × 200	167	19,0	30,0	213	99184	3488	3607	349	21·65 × 7·87	112	·748	1·18	33·0	220



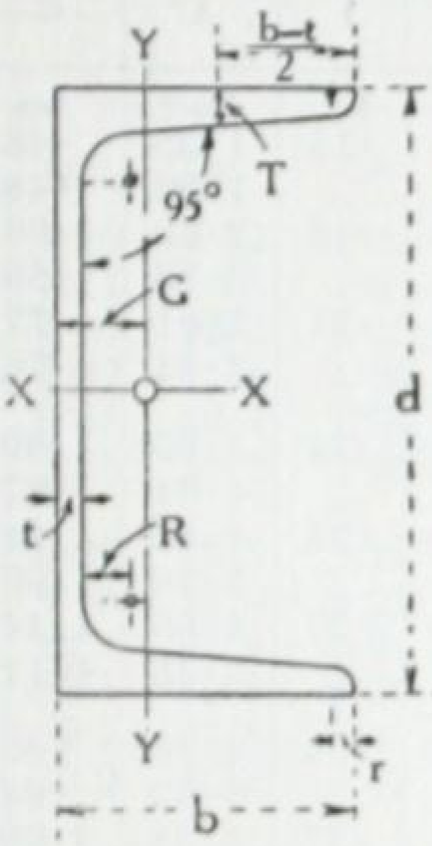
RADII OF FILLETS. R = web thickness (t)
r = ·6 × t
except for section 550 × 200 mm., where R = 19·8 and r = 11·9.

TAPER OF FLANGE. The 14% corresponds to an angle of 97° 58′.

DELIVERY. Large stocks of the above sizes are kept on the Continent. Sizes up to 240 × 106 mm., are rolled frequently, larger sizes rather less frequently.

A section 600 × 215 mm. × 199 kgs/M. is also rolled by one or more mills.

CHANNELS.



British Standard Sizes. PAGE

ROUNDS.

BRITISH STANDARD CHANNELS.

PROPERTIES.

Key Drawing, page 181.

Size.	Weight per Foot.	Delivery.	Web.	Flange.	Radii.		Area.	Centre of Gravity.	Moments of Inertia.		Section Moduli.		Code Word.
d × b			t	T	R	r	A	G	I_x	I_y	Z_x	Z_y	
Ins.	Lb.		Ins.	Ins.	Ins.	Ins.	Ins.[2]	Ins.	Ins.[4]	Ins.[4]	Ins.[3]	Ins.[3]	
3 × 1½	4·60	*a*	·20	·28	·30	·15	1·35	·48	1·82	·26	1·22	·26	CABBY
,,	5·11	*b*	·25	,,	,,	,,	1·50	·48	1·94	·30	1·29	·28	CACHE
4 × 2	7·09	*a*	·24	·31	·36	·18	2·09	·60	5·06	·70	2·53	·50	CADET
,,	7·91	*b*	·30	,,	,,	,,	2·33	·59	5·38	·79	2·69	·54	CAIRN
5 × 2½	10·2	*a*	·25	·38	·42	·21	3·01	·77	11·9	1·64	4·75	·95	CALYX
,,	11·2	*b*	·31	,,	,,	,,	3·31	·76	12·5	1·82	5·00	1·01	CAMEL
6 × 3	12·4	*a*	·25	·38	·48	·24	3·65	·89	21·3	2·83	7·09	1·34	CANNA
,,	13·6	*b*	·31	,,	,,	,,	4·01	·87	22·3	3·10	7·45	1·42	CANOE
,,	16·5	*b*	·38	·48	·48	·24	4·86	·91	26·3	3·70	8·76	1·77	CANTO
,,	17·5	*b*	·43	,,	,,	,,	5·16	·90	27·2	3·95	9·06	1·84	CARAT
6 × 3½	16·5	*a*	·28	·48	·54	·27	4·85	1·14	28·9	5·29	9·63	2·25	CARIB
,,	18·5	*b*	·38	,,	,,	,,	5·45	1·11	30·7	6·05	10·2	2·43	CAROL
7 × 3	14·2	*a*	·26	·42	·48	·24	4·18	·88	32·7	3·26	9·36	1·53	CARVE
,,	17·1	*b*	·38	,,	,,	,,	5·02	·84	36·2	3·87	10·3	1·70	CASTE
7 × 3½	18·3	*a*	·30	·50	·54	·27	5·38	1·09	42·8	5·83	12·2	2·42	CATER
,,	20·2	*b*	·38	,,	,,	,,	5·94	1·07	45·1	6·48	12·9	2·58	CEDAR
8 × 3	16·0	*a*	·28	·44	·48	·24	4·69	·83	46·7	3·58	11·7	1·65	CELLO
,,	18·7	*b*	·38	,,	,,	,,	5·49	·81	51·0	4·11	12·7	1·79	CHAFE
8 × 3½	20·2	*a*	·32	·52	·54	·27	5·94	1·05	60·6	6·37	15·1	2·60	CHALK
,,	23·2	*b*	·43	,,	,,	,,	6·82	1·01	65·3	7·30	16·3	2·81	CHAMP
9 × 3	17·5	*a*	·30	·44	·48	·24	5·14	·78	62·5	3·75	13·9	1·69	CHANT
,,	19·9	*b*	·38	,,	,,	,,	5·86	·76	67·4	4·18	15·0	1·80	CHARM
9 × 3½	22·3	*a*	·34	·54	·54	·27	6·55	1·00	82·6	6·90	18·4	2·76	CHEEK
,,	23·5	*b*	·38	,,	,,	,,	6·91	·99	85·1	7·26	18·9	2·85	CHERT
,,	25·6	*b*	·45	,,	,,	,,	7·54	·97	89·3	7·86	19·8	2·98	CHESS
10 × 3	19·3	*a*	·32	·45	·48	·24	5·67	·74	82·7	3·98	16·5	1·76	CHICK
,,	21·3	*b*	·38	,,	,,	,,	6·27	·73	87·7	4·31	17·5	1·85	CHILL
10 × 3½	24·5	*a*	·36	·56	·54	·27	7·19	·97	110	7·42	21·9	2·93	CHIME
,,	28·5	*b*	·48	,,	,,	,,	8·39	·94	120	8·50	23·9	3·17	CHIRP
11 × 3½	26·8	*c*	·38	·58	·54	·27	7·88	·93	142	7·93	25·8	3·09	CHIVY
,,	30·5	*c*	·48	,,	,,	,,	8·98	·91	153	8·86	27·8	3·30	CHOIR
12 × 3½	26·4	*c*	·38	·50	·54	·27	7·76	·83	160	7·15	26·6	2·68	CHUMP
,,	30·4	*c*	·48	,,	,,	,,	8·96	·81	174	7·96	29·0	2·86	CHYME
12 × 4	31·3	*a*	·40	·60	·60	·30	9·21	1·06	200	12·1	33·3	4·12	CIDER
,,	36·6	*b*	·53	,,	,,	,,	10·8	1·02	219	13·8	36·5	4·44	CLACK
13 × 4	33·2	*c*	·40	·62	·60	·30	9·76	1·04	247	12·8	38·0	4·31	CLANG
,,	38·9	*c*	·53	,,	,,	,,	11·4	1·01	271	14·5	41·6	4·64	CLEEK
15 × 4	36·4	*a*	·41	·62	·60	·30	10·7	·97	349	13·3	46·5	4·40	CLIMB
,,	42·5	*b*	·53	,,	,,	,,	12·5	·94	383	15·0	51·1	4·71	CLOAK
17 × 4	44·3	*a*	·48	·68	·60	·30	13·0	·92	520	15·3	61·2	4·96	CLODS
,,	51·3	*b*	·60	,,	,,	,,	15·1	·91	569	17·0	67·0	5·28	CLOOP

SIZES. The above are the British Standard sizes, 1932. The tabulated breadths are correct only for the minimum standard weights; the heavier weights are obtained by lifting the rolls, thereby increasing the web thickness and flange breadth to the same extent.

TAPER. The angle 95° corresponds to a slope of 8·75%, or 1 in 11 approx.

DELIVERY. The symbols have the following meanings :— *a*, common stock size, frequently rolled; *b*, frequently rolled but seldom stocked; *c*, not readily obtainable in small quantities.

EXTRAS. See page 290.

BRITISH STANDARD CHANNELS.

METRIC PROPERTIES.

Key Drawing, page 181. British Units, page 182.

Size.		Weight per Metre.	Web.	Flange.	Area.	Centre of Gravity.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
d × b			t	T	A	G	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Mm.	Kg.	Mm.	Mm.	$Cm.^2$	Cm.	$Cm.^4$	$Cm.^4$	$Cm.^3$	$Cm.^3$	Mm.	Mm.
3×1½	76·2×38·1	6·85	5·08	7·11	8·72	1·21	75·9	10·9	19·9	4·18	29·5	11·2
,,	76·2×38·2	7·60	6·35	7·11	9·68	1·21	80·7	12·5	21·1	4·59	29·0	11·2
4×2	101·6×50·8	10·55	6·10	7·87	13·4	1·52	211	29·3	41·5	8·23	39·6	14·8
,,	101·6×52·3	11·77	7·62	7·87	15·1	1·50	224	32·9	44·1	8·85	38·6	14·8
5×2½	127·0×63·5	15·21	6·35	9·65	19·4	1·96	494	68·3	77·8	15·6	50·5	18·8
,,	127·0×65·0	16·77	7·87	9·65	21·4	1·93	520	75·8	81·9	16·6	49·3	18·8
6×3	152·4×76·2	18·47	6·35	9·65	23·5	2·26	885	118	116	21·9	61·3	22·4
,,	152·4×77·7	20·35	7·87	9·65	25·9	2·21	930	129	122	23·3	59·9	22·4
6×3	152·4×76·2	24·57	9·65	12·1	31·4	2·31	1094	154	144	29·0	59·2	22·1
,,	152·4×77·5	26·08	10·9	12·1	33·3	2·29	1131	164	148	30·2	58·4	22·4
6×3½	152·4×88·9	24·53	7·11	12·2	31·3	2·90	1202	220	158	36·8	62·0	26·5
,,	152·4×91·4	27·56	9·65	12·2	35·2	2·82	1277	252	168	39·8	60·2	26·5
7×3	177·8×76·2	21·16	6·60	10·7	27·0	2·22	1363	135	153	25·1	71·1	22·4
,,	177·8×79·2	25·40	9·65	10·7	32·4	2·13	1506	161	169	27·9	68·1	22·4
7×3½	177·8×88·9	27·20	7·62	12·7	34·7	2·77	1783	243	200	39·7	71·7	26·4
,,	177·8×90·9	30·03	9·65	12·7	38·3	2·72	1878	270	211	42·3	70·1	26·5
8×3	203·2×76·2	23·75	7·11	11·2	30·3	2·12	1945	149	191	27·1	80·1	22·2
,,	203·2×78·7	27·80	9·65	11·2	35·4	2·06	2122	171	209	29·3	77·5	22·1
8×3½	203·2×88·9	30·08	8·13	13·2	38·3	2·65	2521	265	248	42·5	81·1	26·4
,,	203·2×91·7	34·52	10·9	13·2	44·0	2·57	2717	304	267	46·0	78·5	26·2
9×3	228·6×76·2	25·98	7·62	11·2	33·1	1·98	2602	156	228	27·7	88·6	21·7
,,	228·6×78·2	29·63	9·65	11·2	37·8	1·93	2805	174	245	29·5	86·1	21·6
9×3½	228·6×88·9	33·14	8·64	13·7	42·3	2·55	3439	287	301	45·3	90·2	26·1
,,	228·6×89·9	34·95	9·65	13·7	44·6	2·51	3540	302	310	46·7	89·2	26·1
,,	228·6×91·7	38·15	10·4	13·7	48·6	2·46	3717	327	325	48·8	87·4	25·9
10×3	254·0×76·2	28·69	8·13	11·4	36·6	1·88	3441	166	271	28·9	97·0	21·3
,,	254·0×77·7	31·74	9·65	11·4	40·5	1·85	3649	179	287	30·3	95·0	21·1
10×3½	254·0×88·9	36·40	9·14	14·2	46·4	2·45	4559	309	359	48·0	99·1	25·8
,,	254·0×91·9	42·47	12·2	14·2	54·1	2·39	4975	354	392	51·9	95·8	25·7
11×3½	279·4×88·9	39·85	9·65	14·7	50·8	2·36	5905	330	423	50·6	108	25·4
,,	279·4×91·4	45·41	12·2	14·7	57·9	2·31	6367	369	456	54·1	105	25·1
12×3½	304·8×88·9	39·24	9·65	12·7	50·1	2·11	6648	298	436	43·9	115	24·4
,,	304·8×91·4	45·31	12·2	12·7	57·8	2·06	7248	331	476	46·9	112	23·9
12×4	304·8×101·6	46·62	10·2	15·2	59·4	2·68	8328	504	546	67·4	118	29·1
,,	304·8×104·9	54·51	13·5	15·2	69·5	2·59	9108	574	598	72·8	115	28·7
13×4	330·2×101·6	49·37	10·2	15·7	63·0	2·64	10275	531	622	70·6	128	29·0
,,	330·2×104·9	57·72	13·5	15·7	73·9	2·57	11266	604	682	76·0	123	28·7
15×4	381·0×101·6	54·12	10·4	15·7	69·0	2·46	14530	555	763	72·1	145	28·4
,,	381·0×104·6	63·23	13·5	15·7	80·6	2·39	15935	623	837	77·2	141	27·7
17×4	431·8×101·6	65·99	12·2	17·3	84·1	2·34	21651	635	1003	81·2	160	27·5
,,	431·8×104·6	76·32	15·2	17·3	97·3	2·31	23696	706	1098	86·5	156	26·9

For Code Words and Notes as to the time required for delivery, see page 182.

BRITISH STANDARD CHANNELS AS GIRDERS.

SAFE DISTRIBUTED LOADS : 7½ TONS STRESS.

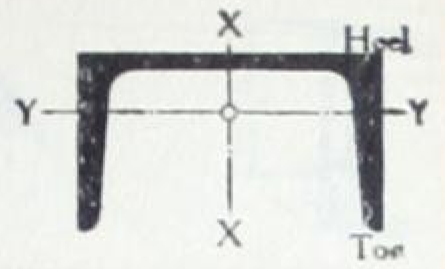
Size. d × b	Weight per Foot.	SAFE LOAD IN TONS. 4′	6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′
Ins.	Lb.													
3 × 1½	4·60	1·5	1·0	·76	·61	...	...	...	...	...	...	...	...	...
,,	5·11	1·6	1·1	·81	·64	...	...	...	...	...	...	...	...	...
4 × 2	7·09	3·2	2·1	1·6	1·3	1·1	...	...	...	...	...	...	...	...
,,	7·91	3·4	2·2	1·7	1·3	1·1	...	...	...	...	...	...	...	...
5 × 2½	10·2	5·9	4·0	3·0	2·4	2·0	1·7	...	...	...	...	...	...	...
,,	11·2	6·2	4·2	3·1	2·5	2·1	1·8	...	...	...	...	...	...	...
6 × 3	12·4	8·9	5·9	4·4	3·5	3·0	2·5	2·2	2·0	...	...	...	...	...
,,	13·6	9·3	6·2	4·7	3·7	3·1	2·7	2·3	2·1	...	...	...	...	...
6 × 3	16·5	11	7·3	5·5	4·4	3·6	3·1	2·7	2·4	...	...	...	...	...
,,	17·5	11	7·5	5·7	4·5	3·8	3·2	2·8	2·5	...	...	...	...	...
6 × 3½	16·5	12	8·0	6·0	4·8	4·0	3·4	3·0	2·7	...	...	...	...	...
,,	18·5	13	8·5	6·4	5·1	4·3	3·7	3·2	2·8	...	...	...	...	...
7 × 3	14·2	12	7·8	5·8	4·7	3·9	3·3	2·9	2·6	2·3	...	...	...	...
,,	17·1	13	8·6	6·4	5·2	4·3	3·7	3·2	2·9	2·6	...	...	...	...
7 × 3½	18·3	15	10	7·6	6·1	5·1	4·4	3·8	3·4	3·1	...	...	...	...
,,	20·2	16	11	8·1	6·5	5·4	4·6	4·0	3·6	3·2	...	...	...	...
8 × 3	16·0	15	9·7	7·3	5·8	4·9	4·2	3·6	3·2	2·9	2·7	2·4	...	...
,,	18·7	16	11	8·0	6·4	5·3	4·6	4·0	3·5	3·2	2·9	2·7	...	...
8 × 3½	20·2	19	13	9·5	7·6	6·3	5·4	4·7	4·2	3·8	3·4	3·2	...	...
,,	23·2	20	14	10	8·2	6·8	5·8	5·1	4·5	4·1	3·7	3·4	...	...
9 × 3	17·5	17	12	8·7	6·9	5·8	5·0	4·3	3·9	3·5	3·2	2·9	2·7	...
,,	19·9	19	12	9·4	7·5	6·2	5·3	4·7	4·2	3·7	3·4	3·1	2·9	...
9 × 3½	22·3	23	15	11	9·2	7·6	6·6	5·7	5·1	4·6	4·2	3·8	3·5	...
,,	23·5	24	16	12	9·4	7·9	6·7	5·9	5·2	4·7	4·3	3·9	3·6	...
,,	25·6	25	17	12	9·9	8·3	7·1	6·2	5·5	5·0	4·5	4·1	3·8	...
10 × 3	19·3	21	14	10	8·3	6·9	5·9	5·2	4·6	4·1	3·8	3·4	3·2	3·0
,,	21·3	22	15	11	8·8	7·3	6·3	5·5	4·9	4·4	4·0	3·7	3·4	3·1
10 × 3½	24·5	27	18	14	11	9·1	7·8	6·8	6·1	5·5	5·0	4·6	4·2	3·9
,,	28·5	30	20	15	12	10	8·5	7·5	6·6	6·0	5·4	5·0	4·6	4·3
11 × 3½	26·8	32	21	16	13	11	9·2	8·1	7·2	6·4	5·9	5·4	5·0	4·6
,,	30·5	35	23	17	14	12	10	8·7	7·7	7·0	6·3	5·8	5·3	5·0
12 × 3½	26·4	33	22	17	13	11	9·5	8·3	7·4	6·7	6·0	5·5	5·1	4·8
,,	30·4	36	24	18	15	12	10	9·1	8·1	7·3	6·6	6·0	5·6	5·2
12 × 4	31·3	38	28	21	17	14	12	10	9·3	8·3	7·6	6·9	6·4	6·0
,,	36·6	46	30	23	18	15	13	11	10	9·1	8·3	7·6	7·0	6·5
13 × 4	33·2	42	32	24	19	16	14	12	11	9·5	8·6	7·9	7·3	6·8
,,	38·9	52	35	26	21	17	15	13	12	10	9·5	8·7	8·0	7·4
15 × 4	36·4	49	39	29	23	19	17	15	13	12	11	9·7	9·0	8·3
,,	42·5	64	43	32	26	21	18	16	14	13	12	11	9·8	9·1
17 × 4	44·3	65	51	38	31	25	22	19	17	15	14	13	12	11
,,	51·3	82	56	42	33	28	24	21	19	17	15	14	13	12

SAFE LOADS AND WORKING STRESS. The Safe Loads, which include the weights of the channels themselves, are calculated for a stress of 7½ tons per square inch by the usual formula, viz., Safe Load in tons × span in feet (centre to centre of bearings) = 5 × Section Modulus. The use of unsymmetrical sections as girders cannot be recommended.

DEFLECTION. The deflection can be ascertained from the table on page 51. Loads printed to the right of the zig-zag line give a deflection exceeding 1/360th of the span, not usually permissible.

BRITISH STANDARD CHANNELS.

PROPERTIES AS STRUTS.



Other Properties, page 182. Key Drawing, page 181.

Size. d × b	Weight per Foot.	Delivery.	Radii of Gyration. g_x	g_y	Bending Moment Multipliers. Flange.	Web. Toe.	Heel.	Flange Load Multiplier.	20 × g_y	Area. A
Ins.	Lb.		Ins.	Ins.					Ft.	Ins.²
3 × 1½	4·60	*a*	1·16	·44	1·11	5·31	2·47	2·67	·73	1·35
,,	5·11	*b*	1·14	·44	1·15	5·53	2·48	2·73	·73	1·50
4 × 2	7·09	*a*	1·56	·58	·82	4·15	1·77	2·65	·97	2·09
,,	7·91	*b*	1·52	·58	·87	4·37	1·75	2·73	·97	2·33
5 × 2½	10·2	*a*	1·99	·74	·63	3·16	1·42	2·58	1·23	3·01
,,	11·2	*b*	1·94	·74	·66	3·29	1·39	2·66	1·23	3·31
6 × 3	12·4	*a*	2·41	·88	·52	2·72	1·15	2·54	1·47	3·65
,,	13·6	*b*	2·36	·88	·54	2·83	1·12	2·62	1·47	4·01
,,	16·5	*b*	2·33	·87	·55	2·76	1·20	2·66	1·45	4·86
,,	17·5	*b*	2·30	·88	·57	2·78	1·16	2·70	1·47	5·16
6 × 3½	16·5	*a*	2·44	1·05	·50	2·14	1·03	2·51	1·75	4·85
,,	18·5	*b*	2·37	1·05	·53	2·26	1·01	2·60	1·75	5·45
7 × 3	14·2	*a*	2·80	·88	·45	2·73	1·13	2·56	1·47	4·18
,,	17·1	*b*	2·68	·88	·49	2·94	1·08	2·71	1·47	5·02
7 × 3½	18·3	*a*	2·82	1·04	·44	2·22	1·01	2·54	1·74	5·38
,,	20·2	*b*	2·76	1·05	·44	2·30	1·01	2·54	1·73	5·94
8 × 3	16·0	*a*	3·16	·87	·40	2·84	1·09	2·60	1·45	4·69
,,	18·7	*b*	3·05	·87	·43	3·03	1·07	2·72	1·45	5·49
8 × 3½	20·2	*a*	3·19	1·04	·39	2·27	·97	2·57	1·73	5·94
,,	23·2	*b*	3·09	1·03	·42	2·45	·95	2·68	1·72	6·82
9 × 3	17·5	*a*	3·49	·86	·37	3·04	1·07	2·66	1·42	5·14
,,	19·9	*b*	3·39	·85	·39	3·21	1·05	2·76	1·42	5·86
9 × 3½	22·3	*a*	3·55	1·03	·36	2·37	·95	2·61	1·71	6·55
,,	23·5	*b*	3·51	1·03	·37	2·40	·93	2·64	1·72	6·91
,,	25·6	*b*	3·44	1·02	·38	2·54	·93	2·71	1·70	7·54
10 × 3	19·3	*a*	3·82	·84	·34	3·22	1·06	2·72	1·40	5·67
,,	21·3	*b*	3·74	·83	·36	3·38	1·06	2·79	1·38	6·27
10 × 3½	24·5	*a*	3·90	1·02	·33	2·46	·93	2·64	1·69	7·19
,,	28·5	*b*	3·77	1·01	·35	2·63	·92	2·76	1·68	8·39
11 × 3½	26·8	*c*	4·24	1·00	·31	2·57	·93	2·68	1·67	7·88
,,	30·5	*c*	4·13	·99	·32	2·74	·93	2·77	1·65	8·98
12 × 3½	26·4	*c*	4·54	·96	·29	2·90	·90	2·75	1·60	7·76
,,	30·4	*c*	4·41	·94	·31	3·16	·92	2·85	1·57	8·96
12 × 4	31·3	*a*	4·66	1·15	·28	2·24	·80	2·66	1·91	9·21
,,	36·6	*b*	4·51	1·13	·29	2·44	·80	2·77	1·88	10·8
13 × 4	33·2	*c*	5·03	1·14	·26	2·28	·80	2·67	1·90	9·76
,,	38·9	*c*	4·86	1·13	·28	2·44	·79	2·79	1·88	11·4
15 × 4	36·4	*a*	5·71	1·12	·23	2·43	·77	2·72	1·86	10·7
,,	42·5	*b*	5·54	1·09	·24	2·68	·79	2·83	1·82	12·5
17 × 4	44·3	*a*	6·32	1·08	·21	2·63	·79	2·81	1·80	13·0
,,	51·3	*b*	6·14	1·06	·23	2·75	·81	2·92	1·77	15·1

DELIVERY. For explanation of symbols, see page 182.

ECCENTRIC LOADS, ETC. Calculate the bending moment (inch-tons) and multiply by the tabulated "Bending Moment Multiplier"; the result, added to the actual vertical load, gives the equivalent central load. The figures headed "Flange" are for bending about the XX axis. If the bending is about the YY axis, use the figures headed "Toe" or "Heel" according to whether the tendency is to bend with the flanges inside or outside.
For further explanation, see pages 96 to 100.

FLANGE LOAD MULTIPLIERS. If the bending moment is produced by a girder connected to the flange, the actual load multiplied by the "Flange Load Multiplier" gives the equivalent central load.

AMERICAN STANDARD STRUCTURAL CHANNELS.

PROPERTIES.

Size.		Weight per Foot.	Thickness.			Fillet Radii.		Centre of Gravity.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
			Web.	Flange.											
d	b		t	T max.	T min.	R	r	G	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
3	1·410	4·1	·170	·377	·170	·27	·10	·44	1·19	1·6	·20	1·1	·21	1·17	·41
,,	1·498	5·0	·258	,,	,,	,,	,,	·44	1·46	1·8	·25	1·2	·24	1·12	·41
,,	1·596	6·0	·356	,,	,,	,,	,,	·46	1·75	2·1	·31	1·4	·27	1·08	·42
4	1·580	5·4	·180	·413	·180	·28	·11	·46	1·56	3·8	·32	1·9	·29	1·56	·45
,,	1·647	6·25	·247	,,	,,	,,	,,	·46	1·82	4·1	·38	2·1	·32	1·50	·45
,,	1·720	7·25	·320	,,	,,	,,	,,	·46	2·12	4·5	·44	2·3	·35	1·47	·46
5	1·750	6·7	·190	·450	·190	·29	·11	·49	1·95	7·4	·48	3·0	·38	1·95	·50
,,	1·885	9·0	·325	,,	,,	,,	,,	·48	2·63	8·8	·64	3·5	·45	1·83	·49
,,	2·032	11·5	·472	,,	,,	,,	,,	·51	3·36	10·4	·82	4·1	·54	1·76	·49
6	1·920	8·2	·200	·487	·200	·30	·12	·52	2·39	13·0	·70	4·3	·50	2·34	·54
,,	2·034	10·5	·314	,,	,,	,,	,,	·50	3·07	15·1	·87	5·0	·57	2·22	·53
,,	2·157	13·0	·437	,,	,,	,,	,,	·52	3·81	17·3	1·1	5·8	·65	2·13	·53
,,	2·279	15·5	·559	,,	,,	,,	,,	·55	4·54	19·5	1·3	6·5	·73	2·07	·53
7	2·090	9·8	·210	·523	·210	·31	·13	·55	2·85	21·1	·98	6·0	·63	2·72	·59
,,	2·194	12·25	·314	,,	,,	,,	,,	·53	3·58	24·1	1·2	6·9	·71	2·59	·58
,,	2·299	14·75	·419	,,	,,	,,	,,	·53	4·32	27·1	1·4	7·7	·79	2·51	·57
,,	2·404	17·25	·524	,,	,,	,,	,,	·55	5·05	30·1	1·6	8·6	·86	2·44	·56
,,	2·509	19·75	·629	,,	,,	,,	,,	·58	5·79	33·1	1·8	9·4	·96	2·39	·56
8	2·260	11·5	·220	·560	·220	·32	·13	·58	3·36	32·3	1·3	8·1	·79	3·10	·63
,,	2·343	13·75	·303	,,	,,	,,	,,	·56	4·02	35·8	1·5	9·0	·86	2·99	·62
,,	2·435	16·25	·395	,,	,,	,,	,,	·56	4·76	39·8	1·8	9·9	·94	2·89	·61
,,	2·527	18·75	·487	,,	,,	,,	,,	·57	5·49	43·7	2·0	10·9	1·0	2·82	·60
,,	2·619	21·25	·579	,,	,,	,,	,,	·59	6·23	47·6	2·2	11·9	1·1	2·77	·60
9	2·430	13·4	·230	·597	·230	·33	·14	·61	3·89	47·3	1·8	10·5	·97	3·49	·67
,,	2·485	15·0	·285	,,	,,	,,	,,	·59	4·39	50·7	1·9	11·3	1·0	3·40	·67
,,	2·648	20·0	·448	,,	,,	,,	,,	·59	5·86	60·6	2·4	13·5	1·2	3·22	·65
,,	2·812	25·0	·612	,,	,,	,,	,,	·61	7·33	70·5	3·0	15·7	1·4	3·10	·64

AMERICAN STANDARD STRUCTURAL CHANNELS.

PROPERTIES.—Continued.

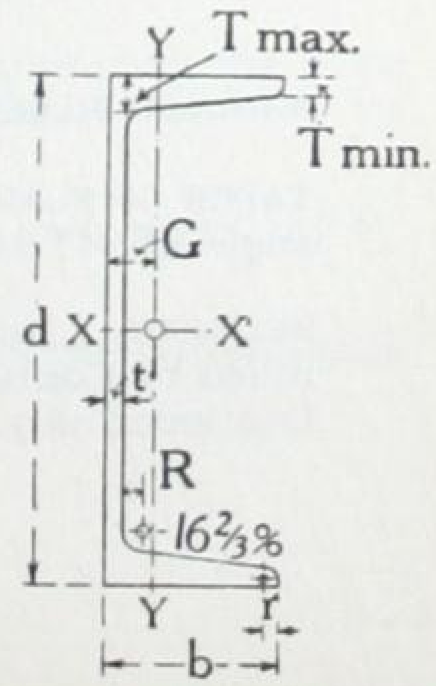
Size.		Weight per Foot.	Thickness.			Fillet Radii.		Centre of Grav-ity.	Area.	Moments of Inertia.		Section Moduli.		Radii of Gyration.	
			Web.	Flange.											
d	b		t	T max.	T min.	R	r	G	A	I_x	I_y	Z_x	Z_y	g_x	g_y
Ins.	Ins.	Lb.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.^{2}	Ins.^{4}	Ins.^{4}	Ins.^{3}	Ins.^{3}	Ins.	Ins.
10	2·600	15·3	·240	·633	·240	·34	·14	·64	4·47	66·9	2·3	13·4	1·2	3·87	·72
,,	2·739	20·0	·379	,,	,,	,,	,,	·61	5·86	78·5	2·8	15·7	1·3	3·66	·70
,,	2·886	25·0	·526	,,	,,	,,	,,	·62	7·33	90·7	3·4	18·1	1·5	3·52	·68
,,	3·033	30·0	·673	,,	,,	,,	,,	·65	8·80	103	4·0	20·6	1·7	3·42	·67
,,	3·180	35·0	·820	,,	,,	,,	,,	·69	10·3	115	4·6	23·0	1·9	3·34	·67
12	2·940	20·7	·280	·723	·280	·38	·17	·70	6·03	128	3·9	21·4	1·7	4·61	·81
,,	3·047	25·0	·387	,,	,,	,,	,,	·68	7·32	143	4·5	23·9	1·9	4·43	·79
,,	3·170	30·0	·510	,,	,,	,,	,,	·68	8·79	161	5·2	26·9	2·1	4·28	·77
,,	3·292	35·0	·632	,,	,,	,,	,,	·69	10·3	179	5·9	29·8	2·3	4·18	·76
,,	3·415	40·0	·755	,,	,,	,,	,,	·72	11·7	196	6·6	32·8	2·5	4·09	·75
13*	4·000	31·8	·375	·880	·340	·48	·23	1·01	9·30	237	11·6	36·5	3·9	5·05	1·11
,,	4·072	35·0	·447	,,	,,	,,	,,	·99	10·2	251	12·5	38·6	4·0	4·95	1·10
,,	4·117	37·0	·492	,,	,,	,,	,,	·98	10·8	259	13·0	39·8	4·2	4·89	1·10
,,	4·185	40·0	·560	,,	,,	,,	,,	·97	11·7	271	13·9	41·7	4·3	4·82	1·09
,,	4·298	45·0	·673	,,	,,	,,	,,	·97	13·2	292	15·3	44·9	4·6	4·71	1·08
,,	4·412	50·0	·787	,,	,,	,,	,,	·98	14·7	313	16·7	48·1	4·9	4·62	1·07
15	3·400	33·9	·400	·900	·400	·50	·24	·79	9·90	313	8·2	41·7	3·2	5·62	·91
,,	3·422	35·0	·422	,,	,,	,,	,,	·79	10·2	319	8·4	42·5	3·2	5·58	·91
,,	3·520	40·0	·520	,,	,,	,,	,,	·78	11·7	346	9·3	46·2	3·4	5·44	·89
,,	3·618	45·0	·618	,,	,,	,,	,,	·79	13·2	374	10·3	49·8	3·6	5·33	·88
,,	3·716	50·0	·716	,,	,,	,,	,,	·80	14·6	401	11·2	53·6	3·8	5·24	·87
,,	3·814	55·0	·814	,,	,,	,,	,,	·82	16·1	429	12·1	57·2	4·1	5·16	·87

TAPER OF FLANGE. The $16\frac{2}{3}$% slope corresponds to a slope of 1 in 6 or an angle of 9° 28′.

RANGE OF WEIGHTS. The first section in each group is the minimum or stock section. The other sections are produced by spacing the rolls.

DELIVERY. These sections are not readily obtainable in Europe, although a number of the larger sizes are obtainable from the Continent, in " rolling quantities " only.

* 13″ × 4″ is not a standard structural size, but is used in car building.



METRIC CHANNELS.

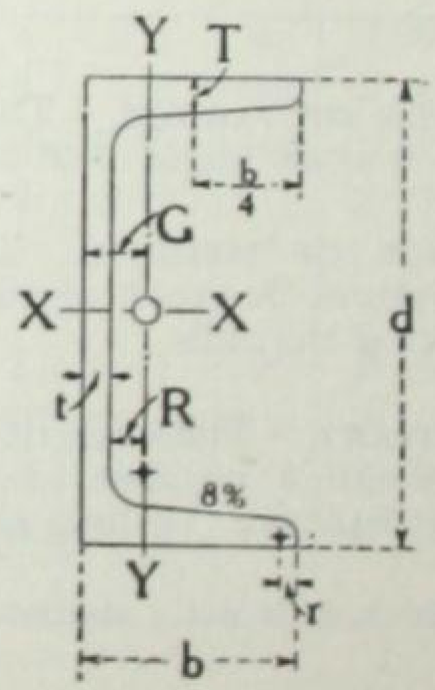
STANDARD CONTINENTAL SECTIONS FOR STRUCTURAL WORK.

METRIC UNITS.									BRITISH UNITS.					
Size.	Weight per Metre.	Thickness.		Area.	Centre of Grav-ity.	Moments of Inertia.		Section Modulus.	Size.	Weight per Foot.	Thickness.		Area.	Section Modulus.
		Web.	Fl.								Web.	Flange.		
d × b		t	T	A	G	I_x	I_y	Z_x	d × b		t	T	A	Z_x
Mm.	Kilos.	Mm.	Mm.	Cm.^{2}	Mm.	Cm.^{4}	Cm.^{4}	Cm.^{3}	Ins.	Lb.	Ins.	Ins.	Ins.^{2}	Ins.^{3}
30 × 33	4,27	5	7	5,44	13,1	6,39	5,33	4,26	**1·18×1·30**	2·87	·197	·276	·843	·260
40 × 35	4,87	5	7	6,21	13,3	14,1	6,68	7,05	**1·57×1·38**	3·28	·197	·276	·963	·433
50 × 38	5,59	5	7	7,12	13,7	26,4	9,12	10,6	**1·97×1·50**	3·76	·197	·276	1·10	·647
65 × 42	7,09	5,5	7,5	9,03	14,2	57,5	14,1	17,7	**2·56×1·65**	4·77	·217	·295	1·40	1·08
80 × 45	8,64	6	8	11,0	14,5	106	19,4	26,5	**3·15×1·77**	5·81	·236	·315	1·71	1·62
100 × 50	10,6	6	8,5	13,5	15,5	206	29,3	41,2	**3·94×1·97**	7·12	·236	·335	2·09	2·51
105 × 65	13,6	8	8	17,3	18,8	287	61,2	54,7	**4·13×2·56**	9·13	·315	·315	2·68	3·34
117½× 65	17,7	10	10	22,6	19,1	447	77,1	76,1	**4·63×2·56**	11·9	·394	·394	3·50	4·64
120 × 55	13,3	7	9	17,0	16,0	364	43,2	60,7	**4·72×2·17**	8·97	·276	·354	2·63	3·70
140 × 60	16,0	7	10	24,4	17,5	605	62,7	86,4	**5·51×2·36**	10·8	·276	·394	3·16	5·27
145 × 60	15,5	8	8	19,8	15,0	585	53,6	80,7	**5·71×2·36**	10·4	·315	·315	3·07	4·93
160 × 65	18,8	7,5	10,5	24,0	18,4	925	85,3	116	**6·30×2·56**	12·7	·295	·413	3·72	7·08
180 × 70	22,0	8	11	28,0	19,2	1354	114	150	**7·09×2·76**	14·8	·315	·433	4·34	9·15
200 × 75	25,3	8,5	11,5	32,2	20,1	1911	148	191	**7·87×2·95**	17·0	·335	·453	4·99	11·7
220 × 80	29,4	9	12,5	37,4	21,4	2690	197	245	**8·66×3·15**	19·7	·354	·492	5·80	15·0
235 × 90	33,3	10	12	42,4	22,8	3429	272	292	**9·25×3·54**	22·4	·394	·472	6·57	17·8
240 × 85	33,2	9,5	13	42,3	22,3	3598	248	300	**9·45×3·35**	22·3	·374	·512	6·56	18·3
260 × 90	32,7	10	10	41,6	19,7	3900	237	300	**10·24×3·54**	21·9	·394	·394	6·45	18·3
260 × 90	37,9	10	14	48,3	23,6	4823	317	371	**10·24×3·54**	25·5	·394	·551	7·49	22·6
280 × 95	41,8	10	15	53,3	25,3	6276	399	448	**11·02×3·74**	28·1	·394	·591	8·26	27·5
300 × 75	33,6	10	10	42,8	15,0	4925	145	328	**11·81×2·95**	22·6	·394	·394	6·63	20·0
300 ×100	46,2	10	16	58,8	27,0	8026	495	535	**11·81×3·94**	31·0	·394	·630	9·11	32·7

RADII OF FILLETS. R = Flange thickness (T). r = ½R.

TAPER OF FLANGE. The taper of 8% corresponds to an angle of 94° 34′, or a slope of 1 in 12½.

DELIVERY. Most of the above sizes are frequently rolled by Continental makers, and freely stocked on the Continent only.



SOLID ROUND STEEL COLUMNS.

PROPERTIES AND SAFE CENTRAL LOADS, B.S.S. FORMULA.

Diameter.	Weight per Foot.	Code Word.	Area.	Radius of Gyration.	Bending Moment Multiplier.	SAFE LOAD IN TONS								
d	Wt.		A	g		4′	6′	8′	10′	12′	14′	16′	18′	20′
Ins.	Lb.		Ins.²	Ins.										
$2\frac{1}{2}$	16·7	ODGAN	4·91	·625	3·20	25	15	9·5	6·4	...	...	...	...	...
3	24·0	ODGUS	7·07	·750	2·67	40	28	19	13	9·2	...	...	...	...
$3\frac{1}{2}$	32·7	ODHOS	9·62	·875	2·29	59	46	32	23	17	13	...	...	...
4	42·7	ODJER	12·6	1·000	2·00	80	67	51	37	27	21	16	...	...
$4\frac{1}{2}$	54·1	ODJME	15·9	1·125	1·78	104	91	73	55	42	32	26	21	...
5	66·8	ODKIT	19·6	1·250	1·60	131	118	99	79	61	48	38	31	25
$5\frac{1}{2}$	80·8	ODLAS	23·8	1·375	1·45	162	148	129	107	85	68	55	45	37
6	96·1	ODLIV	28·3	1·500	1·33	194	180	162	138	113	92	75	61	51
$6\frac{1}{2}$	113	ODONZ	33·2	1·625	1·23	230	216	197	173	146	121	100	82	69
7	131	ODSAB	38·5	1·750	1·14	269	254	235	211	183	154	129	108	91
$7\frac{1}{2}$	150	ODSWE	44·2	1·875	1·07	311	296	276	252	223	192	163	138	117
8	171	ODTAC	50·3	2·000	1·00	356	340	320	296	267	234	202	173	147
$8\frac{1}{2}$	193	ODTED	56·7	2·125	·94	404	386	367	342	313	280	244	211	182
9	216	ODUGS	63·6	2·250	·89	455	437	417	392	363	328	292	255	222
$9\frac{1}{2}$	241	ODUHT	70·9	2·375	·84	508	490	470	445	415	381	343	303	267
10	267	ODYBO	78·5	2·500	·80	563	546	525	500	471	436	396	356	315
$10\frac{1}{2}$	294	ODYCE	86·6	2·625	·76	621	605	585	559	529	494	455	412	369
11	323	ODYDA	95·0	2·750	·73	681	667	645	619	589	555	513	471	426
$11\frac{1}{2}$	353	ODYIJ	104	2·875	·70	746	734	710	684	655	620	579	535	488
12	384	ODYOK	113	3·000	·67	810	800	776	750	720	685	645	600	551

STRESSES AND SAFE LOADS. The tabulated loads are calculated in accordance with the B.S.S. 449—1937 for Columns of which " both ends are held in position but not in direction " (see page 94).

BENDING MOMENT MULTIPLIER. To obtain the equivalent central load producing the same compressive stress as that due to bending, multiply the bending moment in inch-tons by the tabulated multiplier ; add this to the vertical load.

ZIG-ZAG LINE. Heights to the right of the zig-zag line exceed 150g and are only permitted by B.S.S. 449 for subsidiary members in compression.

DELIVERY. Sizes up to 6″ are freely stocked ; for larger sizes special enquiry as to delivery is advisable.

CAPS AND BASES. See pages 150 and 284.

ANGLES AND TEES.

N.B.—Tees cannot be increased in section by lifting the rolls.

ANGLES: EQUAL SIDED.

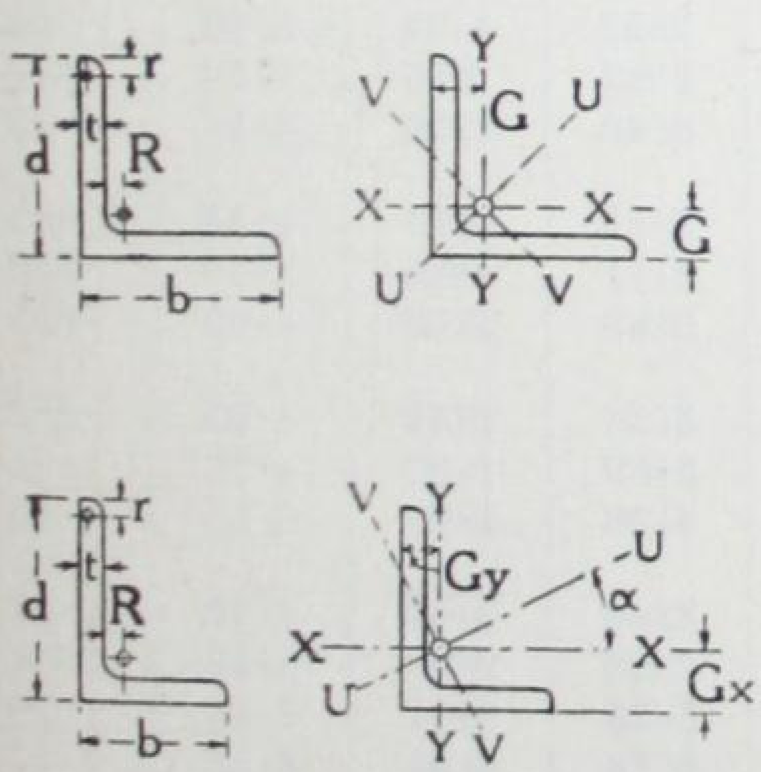
Notes and Key Drawings, page 193. As Struts, page 198. Unequal Angles, page 194.

Size.	Thickness.	Delivery.	Weight per Foot.	Centre of Gravity.	Moments of Inertia.			Section Modulus	Radii of Gyration.			Area.
d × b				G	I_x	I_u	I_v	Z_x	g_x	g_u	g_v	A
Ins.	Ins.		Lb.	Ins.	$Ins.^4$	$Ins.^4$	$Ins.^4$	$Ins.^3$	Ins.	Ins.	Ins.	$Ins.^2$
1 × 1	1/8	*a*	·80	·285	·020	·032	·008	·028	·292	·370	·185	·234
,,	3/16	*a*	1·15	·310	·030	·040	·010	·040	·290	·360	·185	·340
,,	1/4	a	1·49	·335	·036	·055	·016	·053	·285	·355	·191	·437
1¼ × 1¼	1/8	*a*	1·02	·346	·041	·065	·017	·045	·370	·470	·238	·299
,,	3/16	*a*	1·47	·370	·060	·090	·020	·070	·370	·460	·238	·430
,,	1/4	a	1·91	·396	·073	·115	·032	·086	·362	·453	·237	·561
1½ × 1½	3/16	*a*	1·79	·430	·100	·170	·040	·100	·450	·560	·290	·530
,,	1/4	*a*	2·33	·458	·134	·211	·056	·128	·441	·554	·287	·686
,,	5/16	a	2·85	·482	·159	·249	·069	·156	·436	·546	·287	·839
1¾ × 1¾	3/16	*a*	2·11	·495	·172	·273	·071	·137	·526	·662	·338	·622
,,	1/4	*a*	2·77	·521	·220	·349	·092	·180	·520	·655	·336	·814
,,	5/16	a	3·39	·544	·264	·416	·112	·219	·514	·645	·336	·997
2 × 2	3/16	*a*	2·43	·554	·260	·412	·107	·180	·603	·759	·387	·715
,,	1/4	*a*	3·19	·581	·335	·532	·139	·236	·598	·753	·385	·938
,,	5/16	*a*	3·92	·605	·404	·639	·170	·290	·592	·744	·384	1·15
,,	3/8	a	4·62	·629	·467	·735	·200	·341	·586	·735	·383	1·36
2¼ × 2¼	3/16	*c*	2·75	·616	·378	·600	·155	·231	·683	·861	·438	·809
,,	1/4	*a*	3·61	·643	·489	·776	·202	·304	·678	·854	·435	1·06
,,	5/16	*a*	4·45	·668	·592	·937	·247	·374	·672	·846	·434	1·31
,,	3/8	a	5·26	·692	·686	1·08	·290	·441	·666	·837	·433	1·55
2½ × 2½	1/4	*a*	4·04	·703	·677	1·08	·278	·377	·755	·952	·485	1·19
,,	5/16	*a*	4·98	·730	·830	1·31	·340	·470	·750	·950	·480	1·46
,,	3/8	*a*	5·89	·753	·959	1·52	·401	·549	·744	·936	·481	1·73
,,	1/2	a	7·65	·799	1·20	1·89	·520	·707	·731	·916	·481	2·25
3 × 3	1/4	*a*	4·90	·827	1·21	1·92	·495	·555	·916	1·15	·587	1·44
,,	5/16	a	6·04	·850	1·47	2·33	·600	·680	·910	1·15	·580	1·78
,,	3/8	*a*	7·18	·877	1·72	2·73	·714	·812	·904	1·14	·581	2·11
,,	1/2	*a*	9·36	·924	2·18	3·44	·922	1·05	·890	1·12	·579	2·75
3½ × 3½	1/4	*c*	5·74	·950	1·94	3·09	·800	·760	1·07	1·35	·690	1·69
,,	3/8	*a*	8·45	1·00	2·80	4·45	1·15	1·12	1·06	1·34	·681	2·48
,,	1/2	*a*	11·0	1·05	3·57	5·66	1·49	1·46	1·05	1·32	·677	3·25
,,	5/8	b	13·5	1·09	4·27	6·72	1·82	1·77	1·04	1·30	·676	3·98
4 × 4	5/16	c	8·17	1·10	3·61	5·74	1·48	1·24	1·23	1·55	·784	2·40
,,	3/8	*a*	9·72	1·12	4·26	6·77	1·74	1·48	1·22	1·54	·781	2·86
,,	1/2	*a*	12·7	1·17	5·46	8·66	2·26	1·93	1·21	1·52	·776	3·75
,,	5/8	*a*	15·7	1·22	6·56	10·37	2·76	2·36	1·19	1·50	·773	4·61
4½ × 4½	3/8	*b*	11·0	1·24	6·14	9·77	2·51	1·89	1·38	1·74	·882	3·24
,,	1/2	*b*	14·5	1·29	7·92	12·58	3·26	2·47	1·36	1·72	·876	4·25
,,	5/8	*b*	17·8	1·34	9·56	15·14	3·98	3·03	1·35	1·70	·872	5·24
,,	3/4	b	21·0	1·39	11·07	17·46	4·68	3·56	1·34	1·68	·870	6·19

ANGLES: EQUAL SIDED.

—Continued.

Size. d × b	Thickness.	Delivery.	Weight per Foot.	Centre of Gravity. G	Moments of Inertia. I_x	I_u	I_v	Section Modulus Z_x	Radii of Gyration. g_x	g_u	g_v	Area. A
Ins.	Ins.		Lb.	Ins.	Ins.⁴	Ins.⁴	Ins.⁴	Ins.³	Ins.	Ins.	Ins.	Ins.²
5 × 5	3/8	*b*	12·3	1·36	8·51	13·54	3·48	2·34	1·53	1·94	·982	3·61
,,	1/2	*b*	16·1	1·42	11·02	17·52	4·52	3·08	1·52	1·92	·975	4·75
,,	5/8	*b*	19·9	1·47	13·35	21·18	5·52	3·78	1·51	1·90	·970	5·86
,,	3/4	b	23·6	1·51	15·52	24·55	6·50	4·45	1·50	1·88	·967	6·94
6 × 6	3/8	*a*	14·8	1·61	14·99	23·86	6·13	3·42	1·85	2·34	1·19	4·36
,,	1/2	*a*	19·6	1·66	19·52	31·06	7·98	4·50	1·84	2·32	1·18	5·75
,,	5/8	*a*	24·2	1·71	23·77	37·79	9·76	5·55	1·83	2·30	1·17	7·11
,,	3/4	*a*	28·7	1·76	27·78	44·07	11·48	6·56	1·81	2·28	1·17	8·44
7 × 7	1/2	*c*	22·9	1·91	31·42	50·02	12·82	6·17	2·16	2·72	1·38	6·75
,,	5/8	*c*	28·4	1·96	38·45	61·19	15·72	7·63	2·14	2·71	1·37	8·36
,,	3/4	*c*	33·8	2·01	45·12	71·72	18·53	9·04	2·13	2·69	1·37	9·94
,,	7/8	c	39·0	2·06	51·45	81·64	21·27	10·41	2·12	2·67	1·36	11·5
8 × 8	1/2	c	26·3	2·15	47·41	75·48	19·35	8·10	2·47	3·12	1·58	7·75
,,	5/8	*c*	32·7	2·20	58·23	92·70	23·76	10·07	2·46	3·11	1·57	9·61
,,	3/4	*c*	38·9	2·25	68·55	109·1	28·04	11·93	2·45	3·09	1·57	11·4
,,	7/8	*c*	45·0	2·30	78·41	124·6	32·22	13·76	2·43	3·07	1·56	13·2



STANDARD SIZES. The listed sizes of both equal and unequal angles are those of B.S.S. 4A, 1934: standard thicknesses are indicated by the delivery letters being in *italic*. There are other standard thicknesses, used in shipbuilding. Intermediate thicknesses can be produced by spacing the rolls.

DELIVERY. *a* = stock size, frequently rolled.
b = moderate stocks, less frequent rollings.
c = infrequently rolled, seldom stocked.

FILLET RADII. Radii R and r are tabulated on page 205.

WEIGHTS OF ANGLES. See page 204.

EXTRAS. See page 290.

ANGLES: UNEQUAL SIDED.

As Struts, page 198. Notes and Key Drawings, page 193. Equal Angles, page 192.

Size. $d \times b$	Thickness.	Delivery.	Weight per Foot.	Centre of Gravity. G_x	Centre of Gravity. G_y	Moments of Inertia. I_x	Moments of Inertia. I_y	Moments of Inertia. I_u	Moments of Inertia. I_v
Ins.	Ins.		Lb.	Ins.	Ins.	$Ins.^4$	$Ins.^4$	$Ins.^4$	$Ins.^4$
2 × 1½	3/16	b	2·11	·627	·382	·240	·114	·292	·062
,,	1/4	b	2·77	·654	·407	·308	·146	·373	·080
,,	5/16	c	3·39	·678	·431	·369	·174	·446	·098
2½ × 1½	3/16	c	2·43	·830	·340	·450	·120	·490	·070
,,	1/4	c	3·19	·860	·370	·580	·150	·640	·090
,,	5/16	c	3·92	·890	·390	·700	·180	·770	·110
2½ × 2	3/16	a	2·75	·750	·500	·490	·280	·620	·140
,,	1/4	a	3·61	·774	·527	·636	·359	·809	·186
,,	5/16	a	4·45	·799	·552	·771	·433	·977	·227
,,	3/8	b	5·26	·823	·575	·895	·502	1·13	·267
3 × 2	1/4	a	4·04	·976	·482	1·06	·373	1·21	·216
,,	5/16	a	4·98	1·00	·510	1·29	·450	1·48	·260
,,	3/8	a	5·89	1·03	·532	1·50	·525	1·72	·310
3 × 2½	1/4	a	4·46	·895	·648	1·14	·716	1·50	·356
,,	5/16	a	5·51	·920	·670	1·39	·870	1·82	·440
,,	3/8	a	6·53	·945	·697	1·62	1·02	2·13	·512
3½ × 2½	1/4	a	4·90	1·09	·602	1·76	·748	2·09	·415
,,	5/16	a	6·04	1·12	·630	2·14	·910	2·55	·510
,,	3/8	a	7·18	1·15	·652	2·52	1·06	2·98	·596
3½ × 3	1/4	b	5·31	1·01	·767	1·85	1·25	2·50	·608
,,	5/16	a	6·58	1·04	·790	2·27	1·54	3·06	·750
,,	3/8	a	7·81	1·07	·819	2·67	1·80	3·59	·878
,,	1/2	a	10·2	1·11	·867	3·40	2·28	4·54	1·13
4 × 2½	1/4	a	5·31	1·30	·561	2·53	·767	2·85	·455
,,	5/16	a	6·58	1·33	·590	3·11	·940	3·49	·560
,,	3/8	a	7·81	1·35	·612	3·65	1·09	4·09	·655
4 × 3	5/16	a	7·11	1·24	·746	3·31	1·59	4·05	·857
,,	3/8	a	8·45	1·27	·771	3·89	1·87	4·75	1·01
,,	1/2	a	11·0	1·32	·819	4·98	2·37	6·05	1·30
4 × 3½	5/16	b	7·64	1·16	·915	3·46	2·47	4·76	1·17
,,	3/8	b	9·08	1·19	·941	4·08	2·90	5·60	1·38
,,	1/2	b	11·9	1·24	·990	5·23	3·71	7·15	1·79
,,	5/8	b	14·6	1·28	1·04	6·28	4·44	8·55	2·17
4½ × 3	5/16	c	7·64	1·44	·703	4·58	1·63	5·27	·939
,,	3/8	c	9·08	1·47	·728	5·40	1·92	6·20	1·11
,,	1/2	c	11·9	1·52	·777	6·93	2·44	7·95	1·42
,,	5/8	c	14·6	1·57	·824	8·34	2·91	9·51	1·74

ANGLES: UNEQUAL SIDED.—Continued.

Size. d × b	Thickness.	Area. A	Section Moduli. Z_x	Z_y	Radii of Gyration. g_x	g_y	g_u	g_v	Tan α.
Ins.	Ins.	Ins.^{2}	Ins.^{3}	Ins.^{3}	Ins.	Ins.	Ins.	Ins.	
2 × 1½	3/16	·622	·175	·102	·621	·429	·685	·314	·542
,,	1/4	·814	·229	·134	·615	·424	·677	·314	·538
,,	5/16	·997	·280	·163	·609	·418	·669	·313	·531
2½ × 1½	3/16	·710	·270	·100	·790	·410	·830	·320	·350
,,	1/4	·940	·350	·140	·780	·400	·820	·320	·350
,,	5/16	1·15	·430	·170	·780	·400	·820	·320	·350
2½ × 2	3/16	·810	·280	·180	·780	·580	·880	·420	·620
,,	1/4	1·06	·368	·244	·773	·581	·872	·418	·620
,,	5/16	1·31	·453	·299	·767	·575	·864	·416	·616
,,	3/8	1·55	·534	·352	·761	·570	·855	·415	·612
3 × 2	1/4	1·19	·522	·245	·943	·561	1·01	·427	·433
,,	5/16	1·46	·650	·300	·940	·560	1·00	·430	·430
,,	3/8	1·73	·761	·358	·931	·550	·995	·423	·425
3 × 2½	1/4	1·31	·541	·387	·931	·739	1·07	·521	·678
,,	5/16	1·62	·670	·480	·930	·730	1·06	·520	·678
,,	3/8	1·92	·790	·563	·919	·727	1·05	·516	·673
3½ × 2½	1/4	1·44	·743	·394	1·10	·721	1·20	·537	·498
,,	5/16	1·78	·900	·480	1·10	·710	1·20	·530	·496
,,	3/8	2·11	1·07	·575	1·09	·709	1·19	·531	·492
3½ × 3	1/4	1·56	·745	·562	1·09	·896	1·26	·624	·720
,,	5/16	1·93	·920	·700	1·08	·890	1·26	·620	·720
,,	3/8	2·30	1·10	·825	1·08	·885	1·25	·618	·717
,,	1/2	3·00	1·42	1·07	1·06	·872	1·23	·615	·712
4 × 2½	1/4	1·56	·939	·396	1·27	·701	1·35	·540	·387
,,	5/16	1·93	1·17	·490	1·27	·700	1·34	·540	·387
,,	3/8	2·30	1·38	·579	1·26	·690	1·34	·534	·382
4 × 3	5/16	2·09	1·20	·707	1·26	·873	1·39	·640	·548
,,	3/8	2·48	1·42	·838	1·25	·867	1·38	·638	·546
,,	1/2	3·25	1·85	1·09	1·24	·854	1·36	·633	·540
4 × 3½	5/16	2·25	1·22	·954	1·24	1·05	1·45	·722	·752
,,	3/8	2·67	1·45	1·13	1·24	1·04	1·45	·720	·751
,,	1/2	3·50	1·89	1·48	1·22	1·03	1·43	·715	·748
,,	5/8	4·30	2·31	1·80	1·21	1·02	1·41	·711	·744
4½ × 3	5/16	2·25	1·50	·711	1·43	·853	1·53	·647	·437
,,	3/8	2·67	1·78	·842	1·42	·846	1·52	·644	·435
,,	1/2	3·50	2·33	1·10	1·41	·834	1·51	·638	·429
,,	5/8	4·30	2·85	1·34	1·39	·823	1·49	·636	·422

ANGLES: UNEQUAL SIDED.—Continued.

As Struts, page 200. Notes and Key Drawings on page 193. Equal Angles, page 192

Size. d × b	Thickness.	Delivery.	Weight per Foot.	Centre of Gravity. G_x	Centre of Gravity. G_y	Moments of Inertia. I_x	Moments of Inertia. I_y	Moments of Inertia. I_u	Moments of Inertia. I_v
Ins.	Ins.		Lb.	Ins.	Ins.	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}
5 × 3	5/16	a	8·17	1·66	·667	6·13	1·68	6·80	1·01
,,	3/8	a	9·72	1·68	·693	7·24	1·97	8·02	1·19
,,	1/2	a	12·7	1·74	·742	9·33	2·51	10·3	1·54
,,	5/8	c	15·7	1·78	·789	11·2	3·00	12·4	1·87
5 × 3½	5/16	b	8·71	1·56	·822	6·47	2·63	7·63	1·47
,,	3/8	b	10·4	1·59	·848	7·64	3·09	9·01	1·73
,,	1/2	b	13·6	1·64	·897	9·85	3·96	11·6	2·24
,,	5/8	c	16·7	1·69	·944	11·9	4·75	13·9	2·73
5 × 4	3/8	b	11·0	1·51	1·01	7·96	4·53	10·2	2·32
,,	1/2	b	14·5	1·56	1·06	10·3	5·82	13·1	3·01
,,	5/8	c	17·8	1·61	1·11	12·4	7·01	15·8	3·66
6 × 3	3/8	a	11·0	2·12	·632	12·0	2·05	12·7	1·32
,,	1/2	a	14·5	2·17	·683	15·5	2·62	16·4	1·70
,,	5/8	b	17·8	2·22	·731	18·8	3·13	19·8	2·07
6 × 3½	3/8	a	11·6	2·01	·773	12·6	3·22	13·9	1·96
,,	1/2	a	15·3	2·06	·823	16·4	4·14	18·0	2·54
,,	5/8	c	18·9	2·11	·872	19·9	4·97	21·8	3·09
6 × 4	3/8	a	12·3	1·91	·923	13·2	4·73	15·2	2·71
,,	1/2	a	16·1	1·97	·974	17·1	6·10	19·7	3·52
,,	5/8	a	19·9	2·02	1·02	20·8	7·36	23·9	4·29
7 × 3½	7/16	c	15·0	2·47	·740	22·2	3·80	23·6	2·44
,,	1/2	b	17·0	2·50	·765	25·1	4·28	26·6	2·76
,,	5/8	c	21·0	2·55	·814	30·5	5·15	32·3	3·36
7 × 4	1/2	b	17·8	2·39	·903	26·2	6·32	28·7	3·89
,,	5/8	c	22·0	2·44	·953	32·0	7·64	34·9	4·74
,,	3/4	c	26·1	2·49	1·00	37·4	8·86	40·7	5·56
8 × 3½	7/16	c	16·5	2·92	·690	32·1	3·89	33·4	2·59
,,	1/2	c	18·7	2·95	·716	36·3	4·38	37·7	2·93
,,	5/8	c	23·1	3·00	·767	44·3	5·29	46·0	3·57
8 × 4	1/2	b	19·6	2·83	·846	38·0	6·52	40·3	4·19
,,	5/8	b	24·2	2·88	·896	46·4	7·89	49·2	5·11
,,	3/4	c	28·7	2·93	·945	54·4	9·16	57·6	6·00
8 × 6	1/2	c	22·9	2·44	1·45	43·5	21·1	53·3	11·3
,,	5/8	c	28·4	2·49	1·50	53·3	25·7	65·2	13·8
,,	3/4	c	33·8	2·54	1·55	62·6	30·1	76·5	16·2
9 × 4	1/2	c	21·2	3·28	·797	52·5	6·66	54·7	4·42
,,	5/8	c	26·3	3·33	·848	64·3	8·07	67·0	5·40
,,	3/4	c	31·2	3·38	·897	75·5	9·38	78·5	6·34

ANGLES: UNEQUAL SIDED.—Continued.

Size. d × b	Thickness.	Area. A	Section Moduli. Z_x	Section Moduli. Z_y	Radii of Gyration. g_x	Radii of Gyration. g_y	Radii of Gyration. g_u	Radii of Gyration. g_v	Tan a.
Ins.	Ins.	Ins^2.	Ins^3	Ins^3	Ins.	Ins.	Ins.	Ins.	
5 × 3	5/16	2·40	1·84	·719	1·60	·836	1·68	·649	·361
,,	3/8	2·86	2·18	·855	1·59	·831	1·67	·645	·359
,,	1/2	3·75	2·86	1·11	1·58	·819	1·66	·641	·354
,,	5/8	4·61	3·50	1·36	1·56	·807	1·64	·637	·347
5 × 3½	5/16	2·56	1·88	·982	1·59	1·01	1·73	·757	·482
,,	3/8	3·05	2·24	1·17	1·58	1·01	1·72	·754	·480
,,	1/2	4·00	2·93	1·52	1·57	·997	1·70	·748	·475
,,	5/8	4·92	3·60	1·86	1·55	·982	1·68	·744	·470
5 × 4	3/8	3·24	2·28	1·52	1·57	1·18	1·77	·847	·625
,,	1/2	4·25	2·99	1·98	1·55	1·17	1·76	·841	·622
,,	5/8	5·24	3·66	2·43	1·54	1·16	1·74	·837	·618
6 × 3	3/8	3·24	3·09	·864	1·92	·795	1·96	·638	·262
,,	1/2	4·25	4·05	1·13	1·91	·784	1·98	·632	·257
,,	5/8	5·24	4·97	1·38	1·89	·773	1·95	·629	·252
6 × 3½	3/8	3·42	3·17	1·18	1·92	·971	2·01	·757	·344
,,	1/2	4·50	4·16	1·55	1·91	·959	2·00	·751	·340
,,	5/8	5·55	5·11	1·89	1·89	·947	1·98	·746	·335
6 × 4	3/8	3·61	3·23	1·54	1·91	1·14	2·05	·867	·439
,,	1/2	4·75	4·24	2·02	1·90	1·13	2·04	·861	·436
,,	5/8	5·86	5·22	2·47	1·88	1·12	2·02	·855	·431
7 × 3½	7/16	4·40	4·91	1·38	2·25	·930	2·31	·740	·260
,,	1/2	5·00	5·58	1·56	2·24	·925	2·31	·743	·261
,,	5/8	6·17	6·87	1·91	2·22	·913	2·29	·738	·257
7 × 4	1/2	5·25	5·68	2·04	2·24	1·10	2·34	·860	·330
,,	5/8	6·48	7·02	2·50	2·22	1·09	2·32	·855	·326
,,	3/4	7·69	8·30	2·95	2·21	1·07	2·30	·851	·322
8 × 3½	7/16	4·84	6·31	1·39	2·57	·900	2·63	·730	·210
,,	1/2	5·50	7·17	1·57	2·57	·892	2·62	·730	·208
,,	5/8	6·80	8·85	1·93	2·55	·882	2·60	·725	·205
8 × 4	1/2	5·75	7·35	2·07	2·57	1·06	2·65	·853	·263
,,	5/8	7·11	9·07	2·54	2·55	1·05	2·63	·847	·260
,,	3/4	8·44	10·7	3·00	2·54	1·04	2·61	·842	·256
8 × 6	1/2	6·75	7·82	4·63	2·54	1·77	2·81	1·29	·550
,,	5/8	8·36	9·67	5·72	2·52	1·75	2·79	1·28	·550
,,	3/4	9·94	11·5	6·77	2·51	1·74	2·77	1·28	·550
9 × 4	1/2	6·25	9·17	2·08	2·90	1·03	2·96	·841	·216
,,	5/8	7·73	11·3	2·56	2·88	1·02	2·94	·835	·213
,,	3/4	9·19	13·4	3·02	2·86	1·01	2·92	·830	·210

SINGLE ANGLES AS STRUTS.

SAFE LOADS BY BRITISH STANDARD FORMULA.

Vertical Leg.	Horizontal Leg.	Thickness.	Delivery.	Section Modulus.	Radius of Gyration.	Bending Moment Multipliers.		Area.	SAFE CENTRAL LOAD IN TONS.					
				Z_x	g_v	Stem.	Table.	A	4′	6′	8′	10′	12′	14′
Ins.	Ins.	Ins.		Ins.³	Ins.			Ins.²						
1½	1½	3/16	*a*	·100	·290	5·28	2·12	·530	·9	...	...	...	...	...
,,	,,	5/16	a	·156	·287	5·36	2·54	·839	1·4	...	...	...	...	...
1¾	1¾	3/16	*a*	·137	·338	4·54	1·79	·622	1·4	·7	...	...	...	...
,,	,,	5/16	a	·219	·336	4·56	2·06	·997	2·2	1·1	...	...	...	...
2	1½	3/16	*b*	·175	·314	3·56	1·63	·622	1·2	·6	...	...	...	...
,,	,,	5/16	c	·280	·313	3·56	1·83	·997	1·9	·9	...	...	...	...
2	2	3/16	*a*	·180	·387	3·98	1·52	·715	2·0	1·0	...	...	...	...
,,	,,	5/16	*a*	·290	·384	3·98	1·73	1·15	3·2	1·6	...	...	...	...
2¼	2¼	3/16	*c*	·231	·438	3·50	1·32	·809	2·7	1·4	·8	...	...	...
,,	,,	5/16	*a*	·374	·434	3·50	1·48	1·31	4·3	2·2	1·3	...	...	...
2½	1½	3/16	*c*	·270	·320	2·68	1·33	·710	1·4	·7	...	...	...	...
,,	,,	5/16	c	·430	·320	2·65	1·46	1·15	2·3	1·1	...	...	...	...
2½	2	3/16	*a*	·280	·420	2·88	1·23	·810	2·5	1·3	·8	...	...	...
,,	,,	5/16	*a*	·453	·416	2·89	1·36	1·31	4·0	2·1	1·2	...	...	...
2½	2½	1/4	*a*	·377	·485	3·15	1·23	1·19	4·6	2·4	1·5	...	...	...
,,	,,	3/8	*a*	·549	·481	3·16	1·36	1·73	6·6	3·5	2·1	...	...	...
3	2	1/4	*a*	·522	·427	2·28	1·10	1·19	3·7	2·0	1·2	...	...	...
,,	,,	3/8	*a*	·761	·423	2·27	1·19	1·73	5·5	2·8	1·7	...	...	...
3	2½	1/4	*a*	·541	·521	2·43	1·03	1·31	5·5	3·1	1·9	...	...	...
,,	,,	3/8	*a*	·790	·516	2·43	1·12	1·92	8·0	4·4	2·6	...	...	...
3	3	1/4	*a*	·555	·587	2·59	·99	1·44	6·9	4·1	2·4	1·7	...	...
,,	,,	3/8	*a*	·812	·581	2·60	1·07	2·11	10	5·9	3·6	2·4	...	...
3½	2½	1/4	*a*	·743	·537	1·99	·90	1·44	6·2	3·6	2·2	1·4	...	...
,,	,,	3/8	*a*	1·07	·531	1·98	·97	2·11	9·0	5·1	3·1	2·0	...	...
3½	3	1/4	b	·745	·624	2·09	·86	1·56	7·9	4·8	3·0	2·0	...	...
,,	,,	1/2	*a*	1·42	·615	2·13	·99	3·00	15	9·1	5·6	3·7	...	...
3½	3½	1/4	*c*	·760	·690	2·23	·83	1·69	9·2	6·1	3·9	2·6	1·9	...
,,	,,	1/2	*a*	1·46	·677	2·23	·95	3·25	17	11	7·3	5·0	3·6	...
4	2½	1/4	*a*	·939	·540	1·67	·81	1·56	6·8	3·8	2·4	1·6	...	...
,,	,,	3/8	*a*	1·38	·534	1·67	·85	2·30	9·9	5·6	3·5	2·2	...	...
4	3	5/16	*a*	1·20	·640	1·74	·78	2·09	11	6·7	4·2	2·8	2·0	...
,,	,,	1/2	*a*	1·85	·633	1·76	·86	3·25	17	10	6·4	4·3	3·1	...
4	3½	5/16	*b*	1·22	·722	1·85	·76	2·25	13	8·6	5·6	3·7	2·7	2·0
,,	,,	1/2	*b*	1·89	·715	1·85	·83	3·50	19	13	8·7	5·8	4·3	3·1
4	4	3/8	*a*	1·48	·781	1·93	·75	2·86	17	12	8	5·6	3·8	3·0
,,	,,	5/8	*a*	2·36	·773	1·96	·86	4·61	27	19	13	8·7	6·3	4·8

Continued on page 200.

Prayer to Our Lady of Perpetual Succour.

O Virgin Mother of Perpetual Succour, I come before thy sacred picture and with childlike confidence invoke thine aid. Show thyself a Mother to me now and have pity on me. O dearest Mother of Perpetual Succour, for the love thou bearest to Jesus and in honour of His Sacred Wounds, help me in this my necessity (*mention it*). O loving Mother, I leave it all to thee in the name of the Father, I leave it all to thee in the Name of the Son, I leave it all to thee in the name of the Holy Ghost.—Amen.

Our Lady of Perpetual Succour, pray for us (3 times).

Nihil obstat:
J. Donovan,
Censor Deputatus.

Feast Day, June 27th.

AS STRUTS.

TANDARD FORMULA.

						Radii of Gyration.		Area.	SAFE CENTRAL LOAD IN TONS.					
						g_x	g_y	2A	4′	6′	8′	10′	12′	16′
						Ins.	Ins.	Ins.²						
						·45	·75	1·06	3·7	1·9	...	...	...	...
						·44	·80	1·68	5·6	2·9	...	...	...	...
						·53	·86	1·24	5·3	3·0	1·8	...	...	...
						·51	·89	1·99	8·1	4·5	2·7	...	...	...
						·62	·71	1·24	6·2	3·8	2·4	1·6	...	...
						·61	·75	1·99	9·9	6·0	3·7	2·5	...	...
						·60	·96	1·43	7·0	4·2	2·6	1·7	...	...
						·59	·99	2·30	11	6·5	4·0	2·7	...	...
						·68	1·05	1·62	8·7	5·7	3·7	2·5	...	...
						·67	1·09	2·62	14	9·0	5·8	4·0	...	...
						·79	·67	1·42	7·6	4·9	3·1	2·2	...	...
						·78	·70	2·30	13	8·4	5·5	3·6	...	...
						·78	·90	1·62	9·4	6·8	4·6	3·1	2·3	...
						·77	·94	2·62	15	11	7·2	4·9	3·6	...
						·76	1·17	2·38	14	9·7	6·5	4·4	3·1	...
,,	,,					·74	1·20	3·46	20	14	9·0	6·1	4·3	...
3	2	1/4	*a*	3/8	1·04	·94	·87	2·38	15	11	7·8	5·6	4·0	...
,,	,,	3/8	*a*	3/8	1·52	·93	·91	3·46	21	17	12	8·8	6·3	...
3	2½	1/4	*a*	3/8	1·08	·93	1·12	2·62	16	13	9·6	6·9	5·0	...
,,	,,	3/8	*a*	3/8	1·58	·92	1·15	3·84	24	19	14	9·9	7·2	...
3	3	1/4	*a*	3/8	1·11	·92	1·37	2·88	18	14	10	7·5	5·4	...
,,	,,	3/8	*a*	3/8	1·62	·90	1·40	4·22	26	21	15	11	7·6	...
3½	2½	1/4	*a*	3/8	1·49	1·10	1·07	2·88	19	16	12	9·3	7·1	4·3
,,	,,	3/8	*a*	3/8	2·14	1·09	1·10	4·22	27	24	19	14	11	6·5
3½	3	1/4	b	3/8	1·49	1·09	1·31	3·12	20	17	14	10	7·9	4·8
,,	,,	1/2	*a*	3/8	2·84	1·06	1·37	6·00	39	33	26	19	15	8·9
3½	3½	1/4	*c*	3/8	1·52	1·07	1·57	3·38	22	19	15	11	8·3	5·1
,,	,,	1/2	*a*	3/8	2·92	1·05	1·62	6·50	42	36	27	20	16	9·4
4	2½	1/4	*a*	3/8	1·88	1·27	1·03	3·12	20	17	13	9·5	7·3	4·3
,,	,,	3/8	*a*	3/8	2·76	1·26	1·06	4·60	30	25	20	15	11	6·8
4	3	5/16	*a*	1/2	2·40	1·26	1·32	4·18	28	25	21	17	13	8·2
,,	,,	1/2	*a*	1/2	3·70	1·24	1·37	6·50	43	39	33	26	20	12·
4	3½	5/16	*b*	1/2	2·44	1·24	1·57	4·50	30	27	23	18	14	8·6
,,	,,	1/2	*b*	1/2	3·78	1·22	1·61	7·00	46	42	35	27	21	13
4	4	3/8	*a*	1/2	2·96	1·22	1·83	5·72	38	34	28	22	17	11
,,	,,	5/8	*a*	1/2	4·72	1·19	1·89	9·22	61	54	45	35	26	17

Continued on page 201.

SINGLE ANGLES AS STRUTS

SAFE LOADS BY BRI

Vertical Leg.	Horizontal Leg.	Thickness.	Delivery.	Section Modulus.	Radius of Gyration.	Bending Moment Multipliers.								
				Z_x	g_v	Stem.	Table							
Ins.	Ins.	Ins.		Ins.³	Ins.									
1½	1½	3/16	*a*	·100	·290	5·28	2·12							
,,	,,	5/16	a	·156	·287	5·36	2·54							
1¾	1¾	3/16	*a*	·137	·338	4·54	1·79							
,,	,,	5/16	a	·219	·336	4·56	2·06							
2	1½	3/16	*b*	·175	·314	3·56	1·63							
,,	,,	5/16	c	·280	·313	3·56	1·83							
2	2	3/16	*a*	·180	·387	3·98	1·52							
,,	,,	5/16	*a*	·290	·384	3·98	1·73							
2¼	2¼	3/16	*c*	·231	·438	3·50	1·32							
,,	,,	5/16	*a*	·374	·434	3·50	1·48							
2½	1½	3/16	*c*	·270	·320	2·68	1·33							
,,	,,	5/16	c	·430	·320	2·65	1·46							
2½	2	3/16	*a*	·280	·420	2·88	1·23							
,,	,,	5/16	*a*	·453	·416	2·89	1·36							
2½	2½	1/4	*a*	·377	·485	3·15	1·23							
,,	,,	3/8	*a*	·549	·481	3·16	1·36							
3	2	1/4	*a*	·522	·427	2·28	1·10							
,,	,,	3/8	*a*	·761	·423	2·27	1·19							
3	2½	1/4	*a*	·541	·521	2·43	1·03							
,,	,,	3/8	*a*	·790	·516	2·43	1·12							
3	3	1/4	*a*	·555	·587	2·59	·99						...	...
,,	,,	3/8	*a*	·812	·581	2·60	1·07	2·11	10	5·9	3·6	2·4	...	...
3½	2½	1/4	*a*	·743	·537	1·99	·90	1·44	6·2	3·6	2·2	1·4	...	...
,,	,,	3/8	*a*	1·07	·531	1·98	·97	2·11	9·0	5·1	3·1	2·0	...	...
3½	3	1/4	b	·745	·624	2·09	·86	1·56	7·9	4·8	3·0	2·0	...	...
,,	,,	1/2	*a*	1·42	·615	2·13	·99	3·00	15	9·1	5·6	3·7	...	...
3½	3½	1/4	*c*	·760	·690	2·23	·83	1·69	9·2	6·1	3·9	2·6	1·9	...
,,	,,	1/2	*a*	1·46	·677	2·23	·95	3·25	17	11	7·3	5·0	3·6	...
4	2½	1/4	*a*	·939	·540	1·67	·81	1·56	6·8	3·8	2·4	1·6	...	...
,,	,,	3/8	*a*	1·38	·534	1·67	·85	2·30	9·9	5·6	3·5	2·2	...	...
4	3	5/16	*a*	1·20	·640	1·74	·78	2·09	11	6·7	4·2	2·8	2·0	...
,,	,,	1/2	*a*	1·85	·633	1·76	·86	3·25	17	10	6·4	4·3	3·1	...
4	3½	5/16	*b*	1·22	·722	1·85	·76	2·25	13	8·6	5·6	3·7	2·7	2·0
,,	,,	1/2	*b*	1·89	·715	1·85	·83	3·50	19	13	8·7	5·8	4·3	3·1
4	4	3/8	*a*	1·48	·781	1·93	·75	2·86	17	12	8	5·6	3·8	3·0
,,	,,	5/8	*a*	2·36	·773	1·96	·86	4·61	27	19	13	8·7	6·3	4·8

Continued on page 200.

OUR LADY OF PERPETUAL SUCCOUR.

Mary, let perpetual succour
Be the answer to our prayer;
For thy Son of all the wretched
Gives to thee perpetual care.

CHORUS—

Ever-ready help hast thou,
Let thy children feel it now.

Of our passions we are weary,
Weary of the yoke of sin;
Yet, though longing to be holy,
Faint of heart we ne'er begin.

CHORUS—

Ever-ready help hast thou,
Let thy children feel it now.

Let us feel thy help in sorrow,
Mourners look for joy to Thee;
Spurn not God's unhappy creatures,
Whatsoe'er their faults may be

CHORUS—

Ever-ready help hast thou,
Let thy children feel it now.

PAIRS OF ANGLES AS STRUTS.

SAFE LOADS BY BRITISH STANDARD FORMULA.

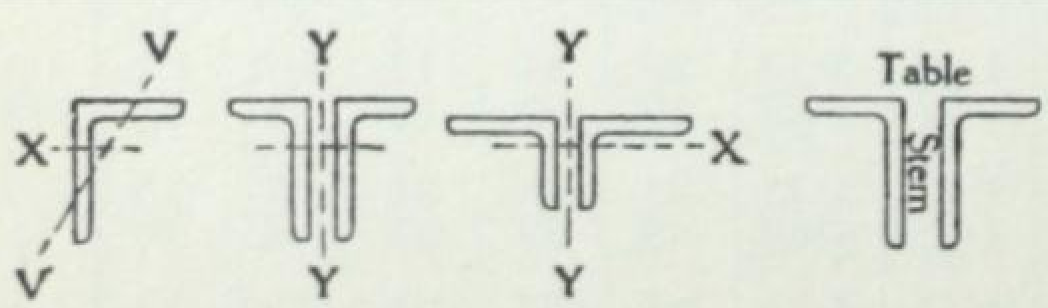
Vertical Leg.	Horizontal Leg.	Thickness.	Delivery.	Distance Apart.	Section Modulus.	Radii of Gyration.		Area.	SAFE CENTRAL LOAD IN TONS.					
				a	$2Z_x$	g_x	g_y	2A	4′	6′	8′	10′	12′	16′
Ins.	Ins.	Ins.		Ins.	Ins.³	Ins.	Ins.	Ins.²						
1½	1½	3/16	a	3/8	·200	·45	·75	1·06	3·7	1·9	...	...	...	...
,,	,,	5/16	a	3/8	·312	·44	·80	1·68	5·6	2·9	...	...	...	...
1¾	1¾	3/16	a	3/8	·274	·53	·86	1·24	5·3	3·0	1·8	...	...	...
,,	,,	5/16	a	3/8	·438	·51	·89	1·99	8·1	4·5	2·7	...	...	...
2	1½	3/16	b	3/8	·350	·62	·71	1·24	6·2	3·8	2·4	1·6	...	...
,,	,,	5/16	c	3/8	·560	·61	·75	1·99	9·9	6·0	3·7	2·5	...	...
2	2	3/16	a	3/8	·360	·60	·96	1·43	7·0	4·2	2·6	1·7	...	...
,,	,,	5/16	a	3/8	·580	·59	·99	2·30	11	6·5	4·0	2·7	...	...
2¼	2¼	3/16	c	3/8	·462	·68	1·05	1·62	8·7	5·7	3·7	2·5	...	...
,,	,,	5/16	a	3/8	·748	·67	1·09	2·62	14	9·0	5·8	4·0	...	...
2½	1½	3/16	c	3/8	·540	·79	·67	1·42	7·6	4·9	3·1	2·2	...	...
,,	,,	5/16	c	3/8	·860	·78	·70	2·30	13	8·4	5·5	3·6	...	...
2½	2	3/16	a	3/8	·560	·78	·90	1·62	9·4	6·8	4·6	3·1	2·3	...
,,	,,	5/16	a	3/8	·906	·77	·94	2·62	15	11	7·2	4·9	3·6	...
2½	2½	1/4	a	3/8	·754	·76	1·17	2·38	14	9·7	6·5	4·4	3·1	...
,,	,,	3/8	a	3/8	1·10	·74	1·20	3·46	20	14	9·0	6·1	4·3	...
3	2	1/4	a	3/8	1·04	·94	·87	2·38	15	11	7·8	5·6	4·0	...
,,	,,	3/8	a	3/8	1·52	·93	·91	3·46	21	17	12	8·8	6·3	...
3	2½	1/4	a	3/8	1·08	·93	1·12	2·62	16	13	9·6	6·9	5·0	...
,,	,,	3/8	a	3/8	1·58	·92	1·15	3·84	24	19	14	9·9	7·2	...
3	3	1/4	a	3/8	1·11	·92	1·37	2·88	18	14	10	7·5	5·4	...
,,	,,	3/8	a	3/8	1·62	·90	1·40	4·22	26	21	15	11	7·6	...
3½	2½	1/4	a	3/8	1·49	1·10	1·07	2·88	19	16	12	9·3	7·1	4·3
,,	,,	3/8	a	3/8	2·14	1·09	1·10	4·22	27	24	19	14	11	6·5
3½	3	1/4	b	3/8	1·49	1·09	1·31	3·12	20	17	14	10	7·9	4·8
,,	,,	1/2	a	3/8	2·84	1·06	1·37	6·00	39	33	26	19	15	8·9
3½	3½	1/4	c	3/8	1·52	1·07	1·57	3·38	22	19	15	11	8·3	5·1
,,	,,	1/2	a	3/8	2·92	1·05	1·62	6·50	42	36	27	20	16	9·4
4	2½	1/4	a	3/8	1·88	1·27	1·03	3·12	20	17	13	9·5	7·3	4·3
,,	,,	3/8	a	3/8	2·76	1·26	1·06	4·60	30	25	20	15	11	6·8
4	3	5/16	a	1/2	2·40	1·26	1·32	4·18	28	25	21	17	13	8·2
,,	,,	1/2	a	1/2	3·70	1·24	1·37	6·50	43	39	33	26	20	12
4	3½	5/16	b	1/2	2·44	1·24	1·57	4·50	30	27	23	18	14	8·6
,,	,,	1/2	b	1/2	3·78	1·22	1·61	7·00	46	42	35	27	21	13
4	4	3/8	a	1/2	2·96	1·22	1·83	5·72	38	34	28	22	17	11
,,	,,	5/8	a	1/2	4·72	1·19	1·89	9·22	61	54	45	35	26	17

Continued on page 201.

SINGLE ANGLES AS STRUTS.

SAFE LOADS—Continued.

Vertical Leg.	Horizontal Leg.	Thickness.	Delivery.	Section Modulus.	Radius of Gyration.	Bending Moment Multipliers.		Area.	SAFE CENTRAL LOAD IN TONS.					
				Z_x	g_v	Stem.	Table.	A	4′	6′	8′	10′	12′	14′
Ins.	Ins.	Ins.		Ins.³	Ins.			Ins.²						
4½	3	5/16	*c*	1·50	·647	1·50	·70	2·25	12	7·3	4·6	3·1	2·2	...
,,	,,	1/2	*c*	2·33	·638	1·55	·76	3·50	18	11	7·0	4·6	3·4	...
4½	4½	3/8	*b*	1·89	·882	1·71	·65	3·24	20	16	11	7·8	5·6	4·2
,,	,,	5/8	*b*	3·03	·872	1·73	·74	5·24	32	25	17	12	9·1	6·8
5	3	5/16	*a*	1·84	·649	1·30	·65	2·40	12	7·8	5·0	3·4	2·4	...
,,	,,	5/8	c	3·50	·637	1·32	·73	4·61	24	15	9·2	6·1	4·4	...
5	3½	3/8	*b*	2·24	·754	1·37	·64	3·05	17	12	8·2	5·5	3·9	3·0
,,	,,	5/8	c	3·60	·744	1·38	·70	4·92	28	19	13	8·7	6·2	4·8
5	4	3/8	*b*	2·28	·847	1·42	·61	3·24	20	15	10	7·3	5·2	3·9
,,	,,	5/8	c	3·66	·837	1·43	·68	5·24	31	24	16	12	8·3	6·3
5	5	3/8	*b*	2·34	·982	1·56	·58	3·61	23	19	14	10	7·6	5·7
,,	,,	5/8	*b*	3·78	·970	1·55	·64	5·86	37	30	23	16	12	9·2
6	3	3/8	*a*	3·09	·638	1·06	·58	3·24	17	10	6·4	4·3	3·1	...
,,	,,	5/8	b	4·97	·629	1·05	·62	5·24	27	16	10	6·8	5·0	...
6	3½	3/8	*a*	3·17	·757	1·08	·55	3·42	20	14	9·2	6·3	4·4	3·5
,,	,,	5/8	c	5·11	·746	1·09	·59	5·55	32	22	15	9·9	7·0	5·5
6	4	3/8	*a*	3·23	·867	1·12	·52	3·61	22	17	12	8·5	6·1	4·6
,,	,,	5/8	*a*	5·22	·855	1·12	·57	5·86	35	27	19	13	9·6	7·2
6	6	3/8	*a*	3·42	1·19	1·28	·47	4·36	29	26	21	16	13	9·9
,,	,,	5/8	*a*	5·55	1·17	1·28	·51	7·11	47	41	34	26	20	16



1. **STRESSES AND SAFE LOADS.** The tabulated loads are calculated by the British Standard formula (B.S.S. 449) for columns "with both ends held in position but unrestrained in direction." For the stresses, see page 95.

2. **ZIG-ZAG LINE.** Lengths to the right of the zig-zag line exceed $150/g$; allowable, by B.S.S. 449, only for subsidiary members in compression.

3. **DELIVERY.** The letters (in italic for British Standard thicknesses) mean :—"*a*" stock size, frequently rolled. "*b*" moderate stocks; less frequently rolled. "*c*" infrequently rolled, seldom stocked. For other thicknesses, see table of properties on pages 192—197.

PAIRS OF ANGLES AS STRUTS.

SAFE LOADS—Continued.

Vertical Leg.	Horizontal Leg.	Thickness.	Delivery.	Distance Apart.	Section Modulus.	Radii of Gyration.		Area.	SAFE CENTRAL LOAD IN TONS.					
				a	$2Z_x$	g_x	g_y	2A	6′	8′	10′	12′	16′	20′
Ins.	Ins.	Ins.		Ins.	Ins.³	Ins.	Ins.	Ins.²						
4½	3	5/16	*c*	1/2	3·00	1·43	1·28	4·50	27	23	19	14	9	6·1
,,	,,	1/2	*c*	1/2	4·66	1·41	1·32	7·00	43	37	30	23	15	10
4½	4½	3/8	*b*	1/2	3·78	1·38	2·03	6·48	40	35	29	23	15	10
,,	,,	5/8	*b*	1/2	6·06	1·35	2·09	10·5	65	56	46	36	23	16
5	3	5/16	*a*	1/2	3·68	1·60	1·24	4·80	29	24	19	15	9	6·2
,,	,,	5/8	c	1/2	7·00	1·56	1·32	9·22	56	49	39	31	20	13
5	3½	3/8	*b*	1/2	4·48	1·58	1·49	6·10	39	35	30	24	16	11
,,	,,	5/8	c	1/2	7·20	1·55	1·55	9·84	63	57	49	41	27	19
5	4	3/8	*b*	1/2	4·56	1·57	1·73	6·48	42	38	33	27	18	13
,,	,,	5/8	c	1/2	7·32	1·54	1·79	10·5	67	61	53	43	29	20
5	5	3/8	*b*	1/2	4·68	1·53	2·23	7·22	46	42	36	30	20	13
,,	,,	5/8	*b*	1/2	7·56	1·51	2·29	11·7	75	67	58	47	31	21
6	3	3/8	*a*	1/2	6·18	1·92	1·19	6·48	38	31	24	19	11	7·7
,,	,,	5/8	b	1/2	9·94	1·89	1·25	10·5	63	53	42	32	20	14
6	3½	3/8	*a*	1/2	6·34	1·92	1·41	6·84	43	38	31	25	17	11
,,	,,	5/8	c	1/2	10·2	1·89	1·47	11·1	70	63	53	43	29	19
6	4	3/8	*a*	1/2	6·46	1·91	1·64	7·22	47	43	38	32	22	15
,,	,,	5/8	*a*	1/2	10·4	1·88	1·69	11·7	76	71	63	54	37	26
6	6	3/8	*a*	5/8	6·84	1·85	2·67	8·72	58	54	49	44	31	23
,,	,,	5/8	*a*	5/8	11·1	1·83	2·73	14·2	94	88	80	71	50	36

4. BENDING MOMENT MULTIPLIERS. To obtain the equivalent central load producing the same compressive stress as that due to bending about the XX axis, multiply the bending moment (inch-tons) by the tabulated multiplier. When the horizontal leg is in compression, use the multiplier headed "Table"; for the vertical leg in compression, use the multiplier headed "Stem." The result, added to the actual vertical load, must not exceed the tabulated safe load. If the bending is about the YY axis for a pair of angles, the value of the multiplier is the horizontal breadth $\div$ $2g_y^2$. For further notes, see page 97.

METRIC STANDARD ANGLES.

Size. d	Size. b	Thickness.	Weight per Metre.	Code Word.
Mm.	Mm.	Mm.	Kilos.	
...	...	...	...	HAKEP
15	15	3	0,64	HANOV
,,	,,	4	0,82	HANRA
20	20	3	0,88	HANSE
,,	,,	4	1,14	HANYX
25	25	3	1,12	HAOCK
,,	,,	4	1,45	HAOGN
30	20	3	1,11	HEBON
,,	,,	4	1,45	HECPO
30	30	4	1,78	HEDIP
,,	,,	6	2,57	HEGUT
35	35	4	2,10	HEGVY
,,	,,	6	3,04	HEIRD
40	20	3	1,35	HEJOV
,,	,,	4	1,77	HEKAS
40	40	4	2,42	HEKET
,,	,,	6	3,52	HEKIV
,,	,,	8	4,55	HEKUX
45	30	4	2,25	HEKWO
,,	,,	5	2,77	HEKZY
45	45	5	3,38	HESED
,,	,,	7	4,60	HESGO
,,	,,	9	5,76	HESIF
50	50	5	3,77	HIFUX
,,	,,	7	5,15	HIPYK
,,	,,	9	6,47	HIRGA

Size. d	Size. b	Thickness.	Weight per Metre.	Code Word.
Mm.	Mm.	Mm.	Kilos.	
55	55	6	4,95	HIRKO
,,	,,	8	6,46	HIRMY
,,	,,	10	7,90	HIWAL
60	30	5	3,37	HIWEM
,,	,,	7	4,59	HIWOP
60	40	5	3,76	HIYAM
,,	,,	7	5,14	HIYIP
60	60	6	5,42	HIZAN
,,	,,	8	7,09	HOARL
,,	,,	10	8,69	HOASM
65	65	7	6,83	HOBOY
,,	,,	9	8,62	HODIZ
,,	,,	11	10,3	HOERM
70	70	7	7,38	HOHBA
,,	,,	9	9,34	HOLEG
,,	,,	11	11,2	HOLFA
75	50	7	6,54	HOLJO
,,	,,	9	8,24	HOMOK
75	75	8	9,03	HOMUL
,,	,,	10	11,1	HONAH
,,	,,	12	13,1	HONNY
80	40	6	5,41	HONOL
,,	,,	8	7,07	HONYN
80	80	8	9,66	HORPO
,,	,,	10	11,9	HOSAM
,,	,,	12	14,1	HOTAN

Size. d	Size. b	Thickness.	Weight per Metre.	Code Word.
Mm.	Mm.	Mm.	Kilos.	
90	90	9	12,2	HOTEP
,,	,,	11	14,7	HUALK
,,	,,	13	17,1	HUATS
100	50	8	9,03	HUAZY
,,	,,	10	11,1	HUBBE
100	65	9	11,2	HUBDO
,,	,,	11	13,4	HUBIC
100	100	10	15,1	HUBYG
,,	,,	12	17,8	HUCOF
,,	,,	14	20,6	HUCUG
110	110	10	16,6	HUDCA
,,	,,	12	19,7	HUDDE
,,	,,	14	22,8	HUFOH
120	80	10	15,0	HUFYK
,,	,,	12	17,8	HUGAF
120	120	11	19,9	HUJUM
,,	,,	13	23,3	HUKEK
,,	,,	15	26,6	HULKA
130	65	10	14,6	HULON
,,	,,	12	17,4	HULUP
130	130	12	23,6	HUMAL
,,	,,	14	27,2	HUMME
,,	,,	16	30,9	HUMPO
140	140	13	27,5	HUMRY
,,	,,	15	31,4	HYBER
,,	,,	17	35,3	HYBTO

Size. d	Size. b	Thickness.	Weight per Metre.	Code Word.
Mm.	Mm.	Mm.	Kilos.	
150	100	12	22,5	HYBWY
,,	,,	14	26,1	HYCAR
150	150	14	31,6	HYCIT
,,	,,	16	35,9	HYCOV
,,	,,	18	40,0	HYELC
160	80	12	21,6	HYTNO
,,	,,	14	25,0	HYUDY
160	160	15	36,2	HYURM
,,	,,	17	40,7	HYVAL
,,	,,	19	45,1	HYVOP
200	100	14	31,6	HYWAM
,,	,,	16	35,9	HYWIP

SIZES. The sizes listed are standards in Belgium, France and Germany. Intermediate thicknesses can be obtained by spacing the rolls. Various other metric sizes are rolled by Continental works, of whom one or two also roll most British Standard *equal* angles up to 6″ × 6″.

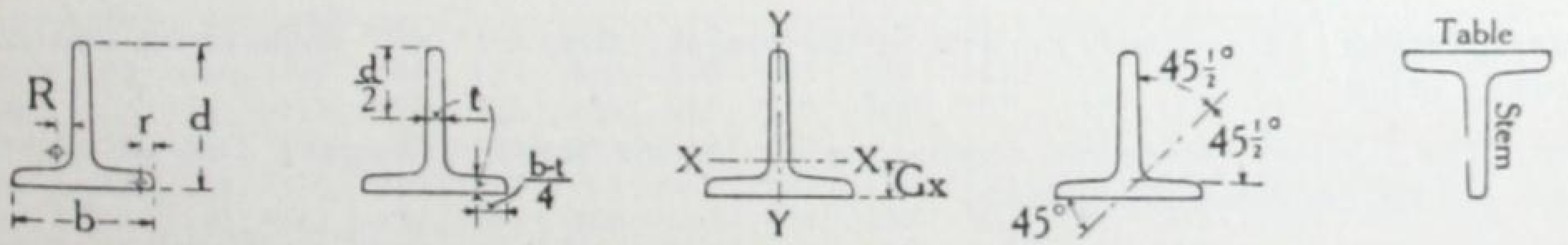
RADII. The radius of the curve at root is in each case equal to the mean of the standard thicknesses. The lesser radius is one-half of this, subject to a minimum of 2 mm.

DELIVERY. The sizes listed are frequently rolled and most of them are freely stocked on the Continent.

BRITISH UNITS. For converting metric weights and dimensions into British, see page 291.

BRITISH STANDARD TEES.

Size.	Thickness.	Delivery.	Weight per Foot.	Centre of Gravity.	Moments of Inertia.		Radii of Gyration.		Section Moduli.		Bending Moment Multipliers.		Area.
b × d				G_x	I_x	I_y	g_x	g_y	Z_x	Z_y	Stem.	Table.	A
Ins.	Ins.		Lb.	Ins.	Ins.⁴	Ins.⁴	Ins.	Ins.	Ins.³	Ins.³			Ins.²
1½ × 1½	3/16	b	1·81	·435	·106	·048	·447	·301	·100	·064	5·31	2·18	·531
,,	1/4	a	2·35	·460	·135	·067	·442	·312	·130	·090	5·32	2·36	·692
2 × 2	1/4	a	3·22	·579	·337	·157	·597	·407	·237	·157	3·99	1·63	·947
,,	3/8	b	4·64	·628	·469	·246	·586	·424	·342	·246	3·99	1·83	1·37
2½ × 2½	1/4	a	4·07	·697	·677	·302	·752	·502	·375	·242	3·18	1·23	1·20
,,	3/8	a	5·92	·750	·859	·472	·742	·521	·548	·378	3·18	1·36	1·74
3 × 3	3/8	a	7·21	·869	1·71	·816	·897	·620	·801	·544	2·65	1·08	2·12
,,	1/2	a	9·38	·918	2·17	1·11	·886	·635	1·04	·742	2·65	1·17	2·76
4 × 3	3/8	a	8·41	·767	·186	1·91	·863	·875	·833	·957	3·00	1·03	2·50
,,	1/2	a	11·1	·816	2·37	2·60	·852	·893	1·08	1·30	3·02	1·12	3·26
4 × 4	3/8	a	9·77	1·11	4·19	1·90	1·21	·814	1·45	·950	1·98	·761	2·87
,,	1/2	a	12·8	1·16	5·40	2·59	1·20	·830	1·90	1·30	1·98	·807	3·76
5 × 3	3/8	a	9·78	·691	1·97	3·72	·828	1·14	·854	1·49	3·37	1·01	2·87
,,	1/2	b	12·8	·741	2·51	5·04	·818	1·16	1·11	2·01	3·39	1·11	3·76
5 × 4	3/8	c	11·1	·998	4·47	3·69	1·17	1·06	1·49	1·48	2·18	·727	3·26
,,	1/2	a	14·5	1·05	5·77	5·02	1·16	1·08	1·96	2·01	2·18	·777	4·27
6 × 3	3/8	b	11·1	·633	2·06	6·39	·795	1·40	·871	2·13	3·74	1·00	3·26
,,	1/2	a	14·5	·684	2·63	8·66	·785	1·42	1·14	2·89	3·75	1·11	4·27
6 × 4	1/2	a	16·2	·968	6·07	8·62	1·13	1·34	2·00	2·87	2·39	·761	4·77
,,	5/8	c	20·0	1·02	7·33	10·9	1·12	1·36	2·46	3·64	2·39	·818	5·88
6 × 6	1/2	c	19·6	1·63	19·0	8·59	1·82	1·22	4·36	2·86	1·32	·494	5·77
,,	5/8	c	24·2	1·69	23·3	10·9	1·81	1·24	5·40	3·63	1·32	·517	7·13



The letters in the delivery column (in italic for British Standard sizes) mean :—
a = Widely stocked. *b* = Frequently stocked. *c* = Stocked by a few merchants.
Sizes up to 4" × 4" are rolled pretty frequently; larger sizes relatively seldom.
The fillet radii are tabulated on page 205.

WEIGHTS PER FOOT

OF BRITISH STANDARD ANGLES AND TEES.

For Iron, deduct 2%.

United Inches.	POUNDS PER FOOT.														
	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
1¾	·58	·84	1·06	...	...	...	...	...	...	...	...	...	...	...	...
2	·80	1·16	1·49	...	...	...	...	...	...	...	...	...	...	...	...
2¼	·90	1·32	1·70	...	...	...	...	...	...	...	...	...	...	...	...
2½	1·02	1·47	1·91	...	...	...	...	...	...	...	...	...	...	...	...
2¾	1·11	1·63	2·12	2·59	...	...	...	...	...	...	...	...	...	...	...
3	1·23	1·79	2·33	2·85	...	...	...	...	...	...	...	...	...	...	...
3¼	...	1·96	2·55	3·12	...	...	...	...	...	...	...	...	...	...	...
3½	...	2·11	2·77	3·39	3·99	...	...	...	...	...	...	...	...	...	...
4	...	2·43	3·19	3·92	4·62	5·30	...	...	...	...	...	...	...	...	...
4¼	...	2·59	3·40	4·18	4·94	5·67	6·38	...	...	...	...	...	...	...	...
4½	...	2·75	3·61	4·45	5·26	6·05	6·80	7·53	...	...	...	...	...	...	...
4¾	...	2·91	3·83	4·72	5·58	6·42	7·23	8·01	...	...	...	...	...	...	...
5	...	3·06	4·04	4·98	5·89	6·78	7·65	8·49	...	...	...	...	...	...	...
5¼	...	3·23	4·25	5·25	6·22	7·16	8·08	8·97	...	...	...	...	...	...	...
5½	...	...	4·46	5·51	6·53	7·53	8·50	9·44	10·4	11·2	...	...	...	...	...
6	...	...	4·90	6·05	7·18	8·28	9·36	10·4	11·4	12·4	13·4	...	...	...	...
6½	...	...	5·31	6·58	7·81	9·02	10·2	11·4	12·5	13·6	14·7	...	...	...	...
7	...	...	5·74	7·11	8·45	9·76	11·0	12·3	13·5	14·8	15·9	...	...	...	...
7½	...	...	6·16	7·64	9·08	10·5	11·9	13·3	14·6	15·9	17·2	...	...	...	...
8	...	...	...	8·17	9·72	11·2	12·7	14·2	15·7	17·1	18·5	...	...	...	...
8½	...	...	...	8·71	10·4	12·0	13·6	15·2	16·7	18·3	19·8	21·2	...	...	...
9	...	...	...	9·23	11·0	12·7	14·5	16·1	17·8	19·4	21·0	22·6	24·2	...	...
9½	...	...	...	...	11·6	13·5	15·3	17·1	18·9	20·6	22·3	24·0	25·7	27·3	...
10	...	...	...	...	12·3	14·2	16·1	18·0	19·9	21·8	23·6	25·4	27·1	28·9	30·6
10½	...	...	...	...	12·9	15·0	17·0	19·0	21·0	22·9	24·9	26·8	28·6	30·5	32·3
11	...	...	...	...	13·5	15·7	17·8	19·9	22·0	24·1	26·1	28·1	30·1	32·1	34·0
11½	...	...	...	...	14·2	16·5	18·7	20·9	23·1	25·3	27·4	29·5	31·6	33·7	35·7
12	...	...	...	...	14·8	17·2	19·6	21·9	24·2	26·4	28·7	30·9	33·1	35·3	37·4
12½	...	...	...	...	15·5	17·9	20·4	22·8	25·2	27·6	30·0	32·3	34·6	36·8	39·1
13	...	...	...	...	16·1	18·7	21·2	23·8	26·3	28·8	31·2	33·7	36·1	38·4	40·8
13½	...	...	...	...	16·7	19·4	22·1	24·7	27·4	29·9	32·5	35·0	37·6	40·0	42·5
14	...	...	...	...	17·4	20·2	23·0	25·7	28·4	31·1	33·8	36·4	39·1	41·6	44·2
15	...	...	...	...	...	...	24·6	27·6	30·5	33·4	36·3	39·2	42·0	44·8	47·6
16	...	...	...	...	...	...	26·3	29·5	32·7	35·8	38·9	41·9	45·0	48·0	51·0
18	...	...	...	...	...	...	29·7	33·3	37·0	40·5	44·0	47·4	51·0	54·4	57·8

UNITED INCHES. This means the sum of the flanges; thus a 4″ × 3″ angle or tee measures 7 united inches.

TEES. The tabulated areas and weights are for British Standard Angles; Tees are slightly more, but the difference is negligible.

AREAS OF HOLES. The lower table on the opposite page shews the deductions to be made for bolt and rivet holes.

SECTIONAL AREAS AND RADII

OF BRITISH STANDARD ANGLES AND TEES.

United Inches.	SECTIONAL AREAS (Sq. Inches).															Fillet Radii.	
d + b	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	R	r
Ins.																Ins.	Ins.
1½	·172	·246	·313	...	...	...	...	...	...	...	...	...	...	...	...	·17	·12
2	·234	·340	·437	...	...	...	...	...	...	...	...	...	...	...	...	·18	·13
2¼	·265	·387	·500	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2½	·299	·433	·561	...	...	...	...	...	...	...	...	...	...	...	...	·20	·14
2¾	·327	·479	·624	·761	...	...	...	...	...	...	...	...	...	...	...	...	...
3	·361	·526	·686	·839	...	...	...	...	...	...	...	...	...	...	...	·21	·15
3¼	...	·575	·751	·919	...	...	...	...	...	...	...	...	...	...	...	...	...
3½	...	·622	·814	·997	1·17	...	...	...	...	...	...	...	...	...	...	·23	·16
4	...	·715	·938	1·15	1·36	1·56	...	...	...	...	...	...	...	...	...	·24	·17
4¼	...	·761	1·00	1·23	1·45	1·67	1·88	...	...	...	...	...	...	...	...	...	...
4½	...	·809	1·06	1·31	1·55	1·78	2·00	2·22	...	...	...	...	...	...	...	·26	·18
4¾	...	·855	1·13	1·39	1·64	1·89	2·13	2·36	...	...	...	...	...	...	...	...	...
5	...	·901	1·19	1·47	1·73	2·00	2·25	2·50	...	...	...	...	...	...	...	·27	·19
5¼	...	·948	1·25	1·54	1·83	2·11	2·38	2·64	...	...	...	...	...	...	...	...	...
5½	...	...	1·31	1·62	1·92	2·21	2·50	2·78	3·05	3·31	...	...	...	...	...	·29	·20
6	...	...	1·44	1·78	2·11	2·44	2·75	3·06	3·36	3·65	3·94	...	...	...	...	·30	·21
6½	...	...	1·56	1·93	2·30	2·65	3·00	3·34	3·67	4·00	4·31	...	...	...	...	·32	·22
7	...	...	1·69	2·09	2·48	2·87	3·25	3·62	3·98	4·34	4·69	...	...	...	...	·33	·23
7½	...	...	1·81	2·25	2·67	3·09	3·50	3·90	4·30	4·68	5·06	...	...	...	...	·35	·24
8	...	...	...	2·40	2·86	3·31	3·75	4·18	4·61	5·03	5·44	...	...	...	...	·36	·25
8½	...	...	...	2·56	3·05	3·53	4·00	4·47	4·92	5·37	5·82	6·25	...	...	...	·38	·26
9	...	...	...	2·72	3·24	3·75	4·25	4·75	5·24	5·72	6·19	6·65	7·11	...	...	·39	·27
9½	...	...	...	...	3·42	3·97	4·50	5·03	5·55	6·06	6·56	7·06	7·55	8·03	...	·41	·29
10	...	...	...	...	3·61	4·18	4·75	5·31	5·86	6·40	6·94	7·47	7·99	8·50	9·00	·42	·29
10½	...	...	...	...	3·80	4·40	5·00	5·59	6·17	6·75	7·31	7·87	8·42	8·97	9·50	·44	·31
11	...	...	...	...	3·98	4·62	5·25	5·87	6·48	7·09	7·69	8·28	8·86	9·43	10·0	...	...
11½	...	...	...	...	4·17	4·84	5·50	6·16	6·80	7·44	8·07	8·68	9·30	9·91	10·5	...	...
12	...	...	...	...	4·36	5·06	5·75	6·44	7·11	7·78	8·44	9·09	9·74	10·4	11·0	·48	·34
12½	...	...	...	...	4·55	5·28	6·00	6·71	7·42	8·12	8·81	9·50	10·2	10·8	11·5	...	...
13	...	...	...	...	4·73	5·50	6·25	7·00	7·73	8·46	9·19	9·90	10·6	11·3	12·0	·51	·36
13½	...	...	...	...	4·92	5·71	6·50	7·28	8·05	8·81	9·56	10·3	11·0	11·8	12·5	...	...
14	...	...	...	...	5·11	5·94	6·75	7·56	8·36	9·16	9·94	10·7	11·5	12·2	13·0	·54	·38
15	...	...	...	...	...	...	7·25	8·12	8·98	9·84	10·7	11·5	12·4	13·2	14·0	...	...
16	...	...	...	...	...	...	7·75	8·68	9·61	10·5	11·4	12·3	13·2	14·1	15·0	·60	·42
18	...	...	...	...	...	...	8·77	9·82	10·9	11·9	12·9	13·9	15·0	16·0	17·0	·66	·46

Dia.	SECTIONAL AREAS OF HOLES.															Dia.
7/16	·055	·082	·109	·137	·164	·191	·219	·246	·273	·301	·328	·355	·383	·410	·437	7/16
1/2	·062	·094	·125	·156	·187	·219	·250	·281	·312	·344	·375	·406	·437	·469	·500	1/2
9/16	·070	·105	·141	·176	·211	·246	·281	·316	·352	·387	·422	·457	·492	·527	·562	9/16
5/8	·078	·117	·156	·195	·234	·273	·312	·352	·391	·430	·469	·508	·547	·586	·625	5/8
11/16	·086	·129	·172	·215	·258	·301	·344	·387	·430	·473	·516	·559	·602	·645	·687	11/16
3/4	·094	·141	·187	·234	·281	·328	·375	·422	·469	·516	·562	·609	·656	·703	·750	3/4
13/16	·102	·152	·203	·254	·305	·355	·406	·457	·508	·559	·609	·660	·711	·762	·812	13/16
7/8	·109	·164	·219	·273	·328	·383	·437	·492	·547	·602	·656	·711	·766	·820	·875	7/8
15/16	·117	·176	·234	·293	·352	·410	·469	·527	·586	·645	·703	·762	·820	·879	·937	15/16
1	·125	·187	·250	·312	·375	·437	·500	·562	·625	·687	·750	·812	·875	·938	1·00	1

RIVETS AND BOLTS.

RIVETS AND BOLTS.

SHEAR AND BEARING VALUES.

3/8″ — Diam. ·375″ Area ·1104″

Shear Stress per sq. in. S	Shear Stress per sq. in. D	Bearing Thickness 10 tns.	Bearing Thickness 11 tns.	Load per Rivet
		Ins.	Ins.	Tons.
...	...	5/16	...	1·17
...	6	...	...	1·16
...	5½	...	...	1·06
...	...	...	1/4	1·03
...	5	...	...	·97
...	...	1/4	...	·94
...	4	...	...	·77
6	...	...	...	·66
5½	...	...	...	·61
...	3	...	...	·58
5	...	...	...	·55
4	...	...	...	·44
3	...	...	...	·33

1/2″ — Diam. ·500″ Area ·1963″

Shear Stress per sq. in. S	Shear Stress per sq. in. D	Bearing Thickness 10 tns.	Bearing Thickness 11 tns.	Load per Rivet
		Ins.	Ins.	Tons.
...	...	7/16	...	2·19
...	6	...	3/8	2·06
...	5½	...	...	1·89
...	...	3/8	...	1·88
...	5	...	5/16	1·72
...	...	5/16	...	1·56
...	...	...	1/4	1·38
...	4	...	...	1·37
...	...	1/4	...	1·25
6	...	...	...	1·18
5½	...	...	...	1·08
...	3	...	...	1·03
5	...	...	...	·98
4	...	...	...	·79
3	...	...	...	·59

5/8″ — Diam. ·625″ Area ·3068″

Shear Stress per sq. in. S	Shear Stress per sq. in. D	Bearing Thickness 10 tns.	Bearing Thickness 11 tns.	Load per Rivet
		Ins.	Ins.	Tons.
...	...	...	1/2	3·43
...	6	...	...	3·22
...	...	1/2	...	3·13
...	...	...	7/16	3·00
...	5½	...	...	2·95
...	...	7/16	...	2·74
...	5	...	...	2·68
...	...	...	3/8	2·58
...	...	3/8	...	2·34
...	4	...	5/16	2·15
...	...	5/16	...	1·95
6	...	...	...	1·84
...	...	...	1/4	1·72
5½	...	...	...	1·69
...	3	...	...	1·61
...	...	1/4	...	1·56
5	...	...	...	1·53
4	...	...	...	1·23
3	...	...	...	·92

3/4″ — Diam. ·750″ Area ·4418″

Shear Stress per sq. in. S	Shear Stress per sq. in. D	Bearing Thickness 10 tns.	Bearing Thickness 11 tns.	Load per Rivet
		Ins.	Ins.	Tons.
...	6	...	9/16	4·64
...	5½	...	...	4·25
...	...	9/16	...	4·22
...	...	...	1/2	4·12
...	5	...	...	3·87
...	...	1/2	...	3·75
...	...	...	7/16	3·61
...	...	7/16	...	3·28
...	4	...	3/8	3·09
...	...	3/8	...	2·81
6	...	...	...	2·65
...	...	...	5/16	2·58
5½	...	...	...	2·43
...	...	5/16	...	2·34
...	3	...	...	2·32
5	...	...	...	2·21
...	...	...	1/4	2·06
...	...	1/4	...	1·87
4	...	...	...	1·77
3	...	...	...	1·32

7/8″ — Diam. ·875″ Area ·6013″

Shear Stress per sq. in. S	Shear Stress per sq. in. D	Bearing Thickness 10 tns.	Bearing Thickness 11 tns.	Load per Rivet
		Ins.	Ins.	Tons.
...	...	...	11/16	6·61
...	6	...	...	6·31
...	...	11/16	5/8	6·02
...	5½	...	...	5·79
...	...	5/8	...	5·46
...	...	...	9/16	5·41
...	5	...	...	5·26
...	...	9/16	...	4·93
...	...	...	1/2	4·81
...	...	1/2	...	4·37
...	4	...	7/16	4·21
...	...	7/16	...	3·83
6	...	...	3/8	3·61
5½	...	...	...	3·31
...	...	3/8	...	3·28
...	3	...	...	3·16
5	...	...	...	3·01
...	...	...	5/16	3·00
...	...	5/16	...	2·74
4	...	...	1/4	2·40
...	...	1/4	...	2·19
3	...	...	...	1·80

1″ — Diam. 1·00″ Area ·7854″

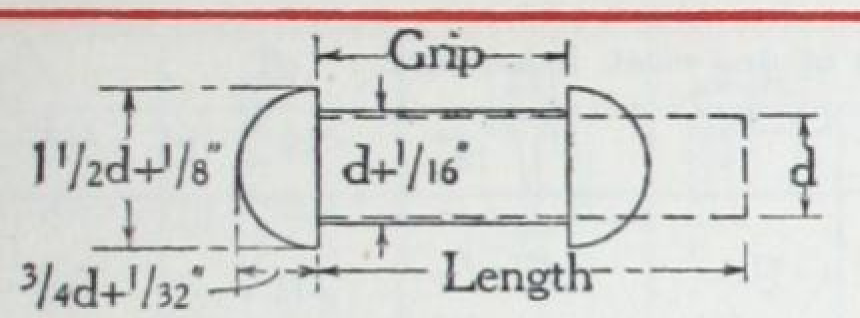
Shear Stress per sq. in. S	Shear Stress per sq. in. D	Bearing Thickness 10 tns.	Bearing Thickness 11 tns.	Load per Rivet
		Ins.	Ins.	Tons.
...	...	7/8	...	8·75
...	6	...	3/4	8·25
...	5½	...	11/16	7·56
...	...	3/4	...	7·50
...	5	11/16	5/8	6·87
...	...	5/8	...	6·25
...	...	...	9/16	6·18
...	...	9/16	...	5·63
...	4	...	1/2	5·50
...	...	1/2	...	5·00
...	...	...	7/16	4·81
6	...	...	...	4·71
...	...	7/16	...	4·38
5½	...	...	...	4·32
...	3	...	3/8	4·12
5	...	...	...	3·93
...	...	3/8	...	3·75
...	...	...	5/16	3·43
4	...	...	...	3·14
...	...	5/16	...	3·13
...	...	...	1/4	2·75
...	...	1/4	...	2·50
3	...	...	...	2·36

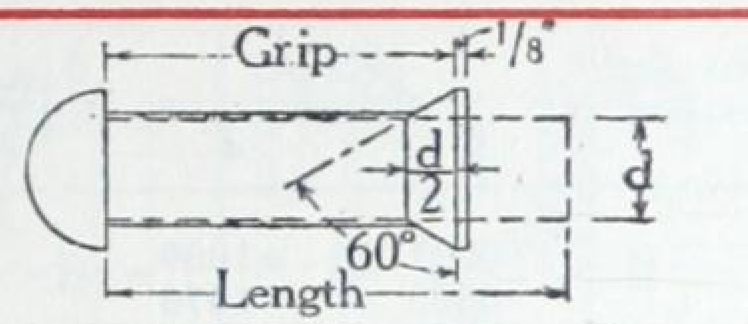
SHEAR STRESSES. S=Single Shear. D=Double Shear. The table shews the safe load in both single and double shear for the various stresses, the value of a rivet in double shear being taken at 1¾ times its value in single shear. (N.B.—British Standard Specification 449—1937 allows 2 × S for double shear.)

BEARING VALUES. The table shews the safe bearing loads for various thicknesses for stresses of 10 and 11 tons respectively. The former enable the loads for any other stress (*e.g.*, 12 tons) to be easily calculated.

LENGTHS OF RIVETS

CORRESPONDING TO VARIOUS GRIPS.

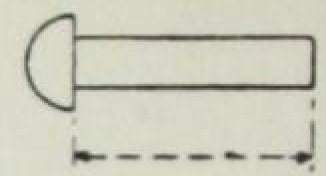




Grip.	Diameter "d."							Diameter "d."							Grip.
	⅜"	½"	⅝"	¾"	⅞"	1"	1⅛"	⅜"	½"	⅝"	¾"	⅞"	1"	1⅛"	
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
½	1⅜	1½	1⅝	1¾	1⅞	2	2⅛	1⅛	1⅛	1¼	1¼	1¼	1¼	1⅜	½
⅝	1⅝	1⅝	1¾	1⅞	2	2⅛	2¼	1⅜	1⅜	1⅜	1⅜	1⅜	1⅜	1½	⅝
¾	1¾	1¾	1⅞	2	2⅛	2¼	2⅜	1½	1½	1½	1½	1½	1⅝	1⅝	¾
⅞	1⅞	2	2	2⅛	2¼	2⅜	2½	1¾	1⅝	1⅝	1⅝	1⅝	1¾	1¾	⅞
1 ...	2⅛	2⅛	2¼	2¼	2⅜	2½	2⅝	1⅞	1¾	1¾	1¾	1⅞	1⅞	1⅞	... 1
1⅛	2¼	2¼	2⅜	2½	2⅝	2⅝	2¾	2	2	2	2	2	2	2	1⅛
1¼	2⅜	2½	2½	2⅝	2¾	2⅞	3	2¼	2⅛	2⅛	2⅛	2⅛	2⅛	2⅛	1¼
1⅜	2⅝	2⅝	2⅝	2¾	2⅞	3	3⅛	2⅜	2¼	2¼	2¼	2¼	2¼	2¼	1⅜
1½	2¾	2¾	2¾	2⅞	3	3⅛	3¼	2½	2½	2⅜	2⅜	2⅜	2⅜	2⅜	1½
1⅝	3	2⅞	3	3	3⅛	3¼	3⅜	2¾	2⅝	2½	2½	2½	2½	2⅝	1⅝
1¾	3⅛	3⅛	3⅛	3⅛	3¼	3⅜	3½	2⅞	2¾	2¾	2⅝	2⅝	2¾	2¾	1¾
1⅞	3¼	3¼	3¼	3⅜	3⅜	3½	3⅝	3	2⅞	2⅞	2⅞	2⅞	2⅞	2⅞	1⅞
2 ...	3½	3⅜	3⅜	3½	3⅝	3⅝	3¾	3¼	3⅛	3	3	3	3	3	... 2
2⅛	3⅝	3½	3⅝	3⅝	3¾	3¾	3⅞	3⅜	3¼	3⅛	3⅛	3⅛	3⅛	3⅛	2⅛
2¼	3¾	3¾	3¾	3¾	3⅞	4	4	3⅝	3⅜	3¼	3¼	3¼	3¼	3¼	2¼
2⅜	4	3⅞	3⅞	3⅞	4	4⅛	4¼	3¾	3½	3½	3⅜	3⅜	3⅜	3⅜	2⅜
2½	4⅛	4	4	4⅛	4⅛	4¼	4⅜	3⅞	3¾	3⅝	3⅝	3½	3½	3½	2½
2⅝	...	4⅛	4⅛	4¼	4¼	4⅜	4½	...	3⅞	3¾	3¾	3¾	3⅝	3⅝	2⅝
2¾	...	4⅜	4⅜	4⅜	4⅜	4½	4⅝	...	4	3⅞	3⅞	3⅞	3⅞	3⅞	2¾
2⅞	...	4½	4½	4½	4⅝	4⅝	4¾	...	4⅛	4⅛	4	4	4	4	2⅞
3 ...	...	4⅝	4⅝	4⅝	4¾	4¾	4⅞	...	4⅜	4¼	4⅛	4⅛	4⅛	4⅛	... 3
3⅛	...	...	4¾	4¾	4⅞	5	5	...	...	4⅜	4¼	4¼	4¼	4¼	3⅛
3¼	...	...	4⅞	5	5	5⅛	5⅛	...	...	4½	4½	4⅜	4⅜	4⅜	3¼
3⅜	...	...	5⅛	5⅛	5⅛	5¼	5¼	...	...	4⅝	4⅝	4½	4½	4½	3⅜
3½	...	...	5¼	5¼	5¼	5⅜	5½	...	...	4⅞	4¾	4¾	4⅝	4⅝	3½
3⅝	...	...	...	5⅜	5⅜	5½	5⅝	...	...	...	4⅞	4⅞	4¾	4¾	3⅝
3¾	...	...	...	5½	5⅝	5⅝	5¾	...	...	...	5	5	5	5	3¾
3⅞	...	...	...	5⅝	5¾	5¾	5⅞	...	...	...	5⅛	5⅛	5⅛	5⅛	3⅞
4 ...	...	...	...	5⅞	5⅞	5⅞	6	...	...	...	5⅜	5¼	5¼	5¼	... 4
4⅛	...	...	...	...	6	6⅛	6⅛	...	...	...	...	5⅜	5⅜	5⅜	4⅛
4¼	...	...	...	...	6⅛	6¼	6¼	...	...	...	...	5½	5½	5½	4¼
4⅜	...	...	...	...	6¼	6⅜	6⅜	...	...	...	...	5¾	5⅝	5⅝	4⅜
4½	...	...	...	...	6⅜	6½	6⅝	...	...	...	...	5⅞	5¾	5¾	4½
4⅝	...	...	...	...	...	6⅝	6¾	...	...	...	...	...	6	5⅞	4⅝
4¾	...	...	...	...	...	6¾	6⅞	...	...	...	...	...	6⅛	6	4¾
4⅞	...	...	...	...	...	6⅞	7	...	...	...	...	...	6¼	6¼	4⅞
5 ...	...	...	...	...	...	7	7⅛	...	...	...	...	...	6¾	6⅜	... 5
Formulæ for Length.	·67+1·36 grip	·80+1·27 grip	·93+1·21 grip	1·07+1·17 grip	1·21+1·15 grip	1·35+1·13 grip	1·49+1·11 grip	·44+1·36 grip	·48+1·27 grip	·53+1·21 grip	·57+1·17 grip	·61+1·15 grip	·66+1·13 grip	·70+1·11 grip	Formulæ for Length.

The tabulated lengths are for hydraulic riveting. For pneumatic and hand riveting, deduct 1/8" and 1/4" respectively.
The formulæ provide for heads of the dimensions shewn and for the hole being of a diameter 1/16" greater than the shank, taper neglected.

WEIGHTS OF STEEL RIVETS.



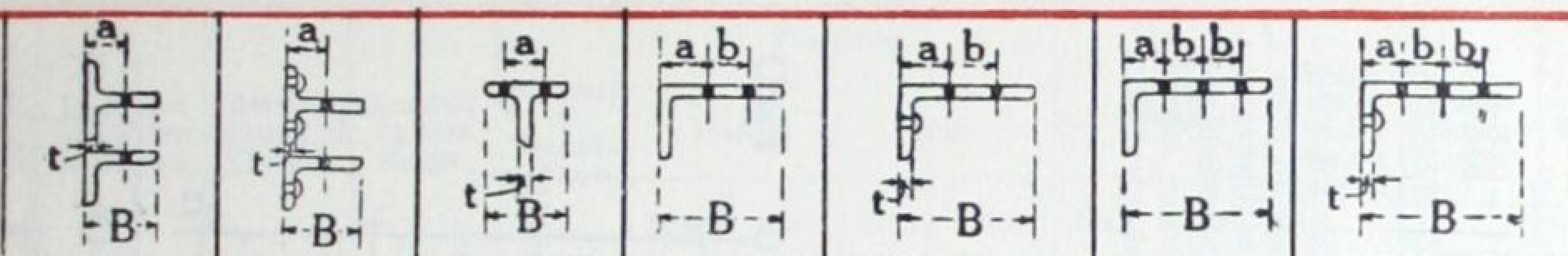
Length (Inches).	Weight of one rivet, in pounds.						
	⅜"	½"	⅝"	¾"	⅞"	1"	1⅛"
1	·0521	·1000	...	...	...	...	...
1⅛	·0560	·1070	...	...	...	...	...
1¼	·0599	·1139	...	...	...	...	...
1⅜	·0638	·1209	·2006	·3061	...	...	...
1½	·0677	·1278	·2115	·3218	...	...	...
1⅝	·0716	·1348	·2224	·3374	...	...	...
1¾	·0755	·1418	·2332	·3531	...	...	...
1⅞	·0794	·1487	·2441	·3687	·5255	·7171	·9469
2	·0834	·1557	·2550	·3843	·5467	·7450	·9821
2⅛	·0873	·1626	·2658	·4000	·5680	·7728	1·0173
2¼	·0912	·1696	·2767	·4156	·5893	·8006	1·0525
2⅜	·0951	·1765	·2875	·4313	·6106	·8284	1·0877
2½	·0990	·1835	·2984	·4469	·6319	·8562	1·1229
2⅝	·1029	·1904	·3093	·4626	·6532	·8840	1·1581
2¾	·1069	·1974	·3201	·4782	·6745	·9119	1·1933
2⅞	·1108	·2043	·3310	·4939	·6958	·9397	1·2285
3	·1147	·2113	·3419	·5095	·7171	·9675	1·2637
3⅛	·1186	·2183	·3527	·5252	·7384	·9953	1·2989
3¼	·1225	·2252	·3636	·5408	·7597	1·0231	1·3341
3⅜	·1264	·2322	·3745	·5565	·7810	1·0509	1·3693
3½	·1303	·2391	·3853	·5721	·8023	1·0788	1·4045
3⅝	...	·2461	·3962	·5878	·8236	1·1066	1·4397
3¾	...	·2530	·4071	·6034	·8449	1·1344	1·4750
3⅞	...	·2600	·4179	·6190	·8662	1·1622	1·5102
4	...	·2669	·4288	·6347	·8875	1·1900	1·5454
4⅛	...	...	·4397	·6503	·9088	1·2178	1·5806
4¼	...	...	·4505	·6660	·9301	1·2457	1·6158
4⅜	...	...	·4614	·6816	·9514	1·2735	1·6510
4½	...	...	·4723	·6973	·9727	1·3013	1·6862
4⅝	...	...	...	·7129	·9940	1·3291	1·7214
4¾	...	...	...	·7286	1·0153	1·3569	1·7566
4⅞	...	...	...	·7442	1·0366	1·3847	1·7918
5	...	...	...	·7599	1·0579	1·4126	1·8270
5⅛	...	...	...	...	1·0792	1·4404	1·8622
5¼	...	...	...	...	1·1005	1·4682	1·8974
5⅜	...	...	...	...	1·1218	1·4960	1·9326
5½	...	...	...	...	1·1431	1·5338	1·9678
5⅝	...	...	...	...	...	1·5516	2·0030
5¾	...	...	...	...	...	1·5795	2·0382
5⅞	...	...	...	...	...	1·6073	2·0734
6	...	...	...	...	...	1·6351	2·1086
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
⅛" of Shank	·0039	·0070	·0109	·0156	·0213	·0278	·0352
1" of Shank	·0313	·0556	·0869	·1252	·1704	·2225	·2816
1 Rivet Head	·0208	·0444	·0811	·1340	·2060	·2999	·4188
C'sk, deduct	·0168	·0348	·0624	·1017	·1546	·2233	·3097

Weights in this table are for cup-headed rivets with cylindrical shanks; for dimensions of heads, see page 209.

Countersunk heads are herein taken as having a taper of 60°, and a depth half the diameter.

The lengths of Cup Head Rivets are measured from under head to point; countersunk rivets overall.

STANDARDS FOR RIVET SPACING.



BREADTH. B	a	d	t	a	d	t	a	d	t	a	b	d	a	b	d	t	a	b	d	a	b	d	t	BREADTH. B
10	...	...	...	...	...	...	...	...	...	3 3/4	4	...	3 3/4	4	...	...	2 1/2	2 7/8	7/8	2 1/2	2 7/8	7/8	3/4	10
9	...	...	...	...	...	...	...	...	...	3 1/2	3 1/2	...	3 1/2	3 1/2	...	...	2	2 3/4	7/8	2 7/16	2 5/8	7/8	3/4	9
8	...	...	...	...	...	...	4 3/4	...	...	3	3	1	3	3	1	1	2	2 1/4	3/4	2 1/4	2 1/4	3/4	3/4	8
7 1/2	...	...	...	...	...	...	4 1/2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7 1/2
7	...	...	...	...	...	...	4	1	...	2 1/2	3	1	2 5/8	2 7/8	7/8	7/8	2	1 3/4	1 x	2 1/4	1 3/4	3/4 x	3/4	7
6 1/2	3 1/2	...	...	3 1/2	...	...	3 3/4	7/8	...	2 3/8	2 5/8	7/8	2 1/2	2 5/8	7/8	3/4	2	1 1/2	1 x	2 1/4	1 1/2	3/4 x	3/4	6 1/2
6	3 1/4	...	...	3 1/4	...	...	3 3/8 z	7/8	...	2	2 5/8	7/8	2 1/4	2 1/4	3/4	3/4	2	1 1/4	3/4 x	2 1/4	1 1/4	3/4 x	3/4	6
5 1/2	3	...	...	3	...	...	3	3/4	...	2	2 1/4	3/4	2 1/4	2	3/4 x	3/4	...	...	...	...	...	...	...	5 1/2
5	2 3/4	...	...	2 3/4	...	...	2 3/4	3/4	...	2	1 3/4	3/4 x	2 1/4	1 1/2	3/4 x	3/4	...	...	...	...	...	...	...	5
4 1/2	2 1/2	...	...	2 1/2	7/8	3/4	2 1/2	5/8	...	1 7/8	1 1/2	3/4 x	2 1/8	1 1/4	3/4 x	5/8	...	...	...	...	...	...	...	4 1/2
4	2 1/4	...	...	2 1/2	7/8	3/4	2 1/8 y	5/8	9/16	1 3/4	1	3/4 x	...	...	...	...	...	...	...	...	...	...	...	4
3 1/2	2	...	...	2 1/4	3/4	3/4	1 3/4	1/2	3/8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3 1/2
3	1 3/4	3/4	...	1 7/8	5/8	9/16	1 1/2	3/8	5/16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
2 3/4	1 5/8	3/4	...	...	...	...	1 3/8	3/8 w	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2 3/4
2 1/2	1 3/8	3/4	1/2	...	...	...	1 1/4	3/8 w	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2 1/2
2 1/4	1 1/4	5/8	7/16	...	...	...	1 1/8	3/8 w	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2 1/4
2	1 1/16	5/8	1/4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
1 3/4	1	1/2	5/16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1 3/4
1 1/2	7/8	3/8	1/4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1 1/2

d = Maximum diameter of rivet.
t = Maximum thickness for the adjacent web or flange if the rivets are to be machine-driven in the standard positions.

w = Hand-driven rivets.
x = Rivets must be staggered.
y = 2 1/4″ is usual.
z = 3 1/2″ is common both for 3/4″ and 7/8″ rivets.

ASSUMED DIMENSIONS AND CLEARANCES.

	Formula.	3/8″	1/2″	5/8″	3/4″	7/8″	1″
Minimum Distance from adjacent Rivet	3d	1 1/8	1 1/2	1 7/8	2 1/4	2 5/8	3
,, ,, ,, Edge	1 1/2 d	9/16	3/4	15/16	1 1/8	1 5/16	1 1/2
Diameter of Rivet Head (D)	1 1/2 d + 1/8″	11/16	7/8	1 1/16	1 1/4	1 7/16	1 5/8
Height ,, ,, ,, (H)	1/2 D − 1/32″	5/16	13/32	1/2	19/32	11/16	25/32
Clearance for Machine Driving	1/2 D + 1/4″	19/32	11/16	25/32	7/8	31/32	1 1/16
,, plus Height of Rivet Head ...	H + 1/2 D + 1/4″	29/32	1 3/32	1 9/32	1 15/32	1 21/32	1 27/32

The British Standard dimensions of rivet heads are: Diameter, 1·6*d*; height, 0·7*d*. For tolerances, see B.S.S. 275 (1927). Rivet sizes in odd sixteenths of an inch should be avoided, if possible.

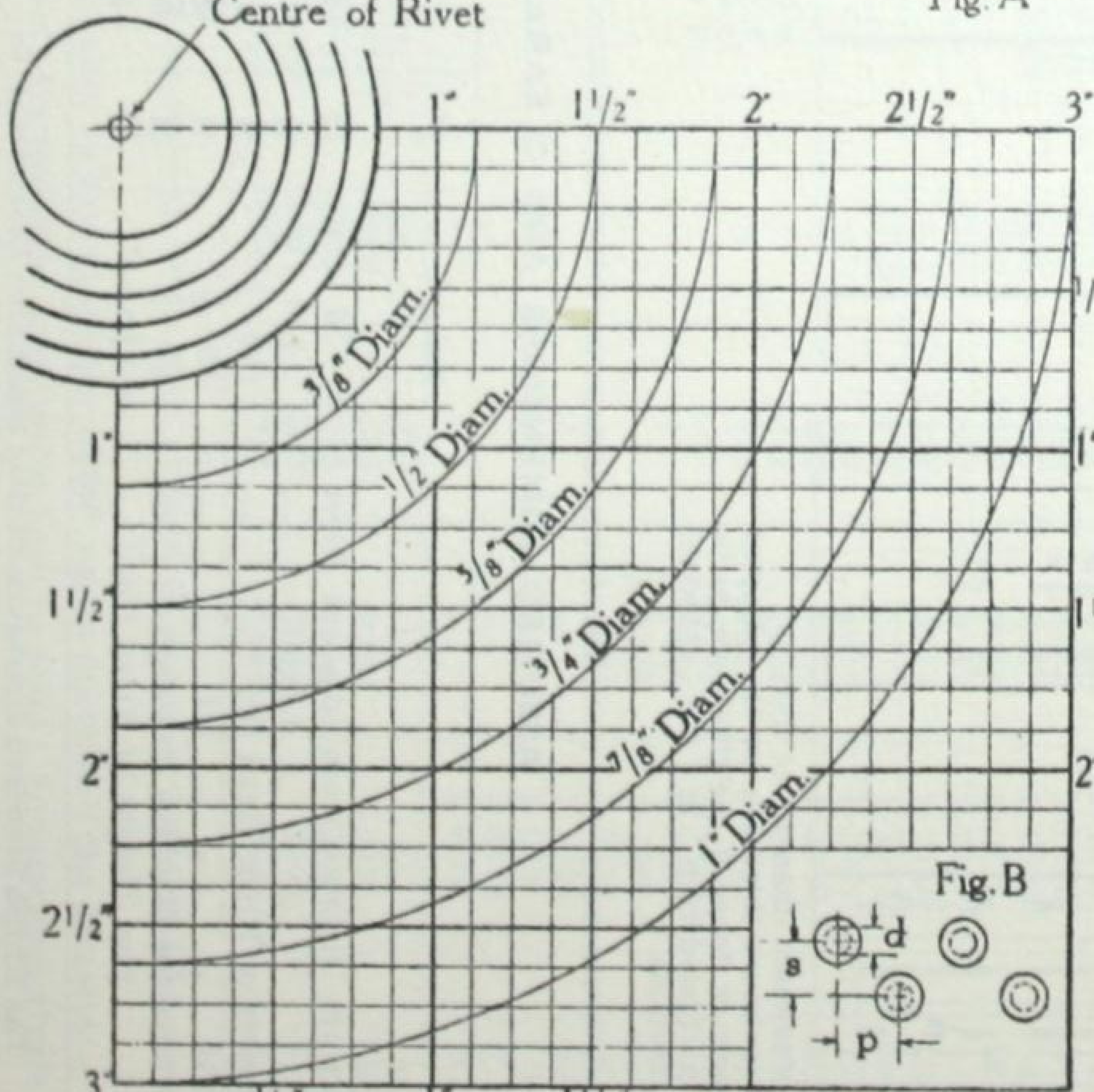
RIVET SPACING.

The diagrams below, drawn actual size, shew the limiting positions for the centres of adjacent rivets of various diameters.

The circular arcs in Fig. A below, drawn actual size, shew the closest allowable positions of the centre of a rivet in relation to an adjacent rivet (shewn in the top left-hand corner of the diagram) when the distance centre to centre is to be not less than 3 times the diameter—this being the minimum usually observed in structural work.

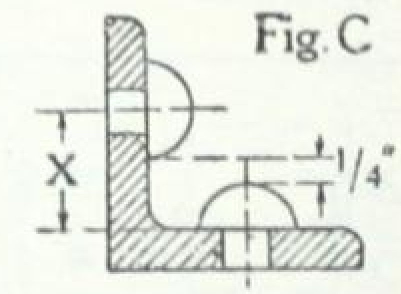
If the rivets are staggered as in the inset Fig. B, and the foregoing rule is to be observed, the diagram will shew at a glance the smallest allowable value for *s* for a given longitudinal half pitch *p*, and conversely.

Fig. A



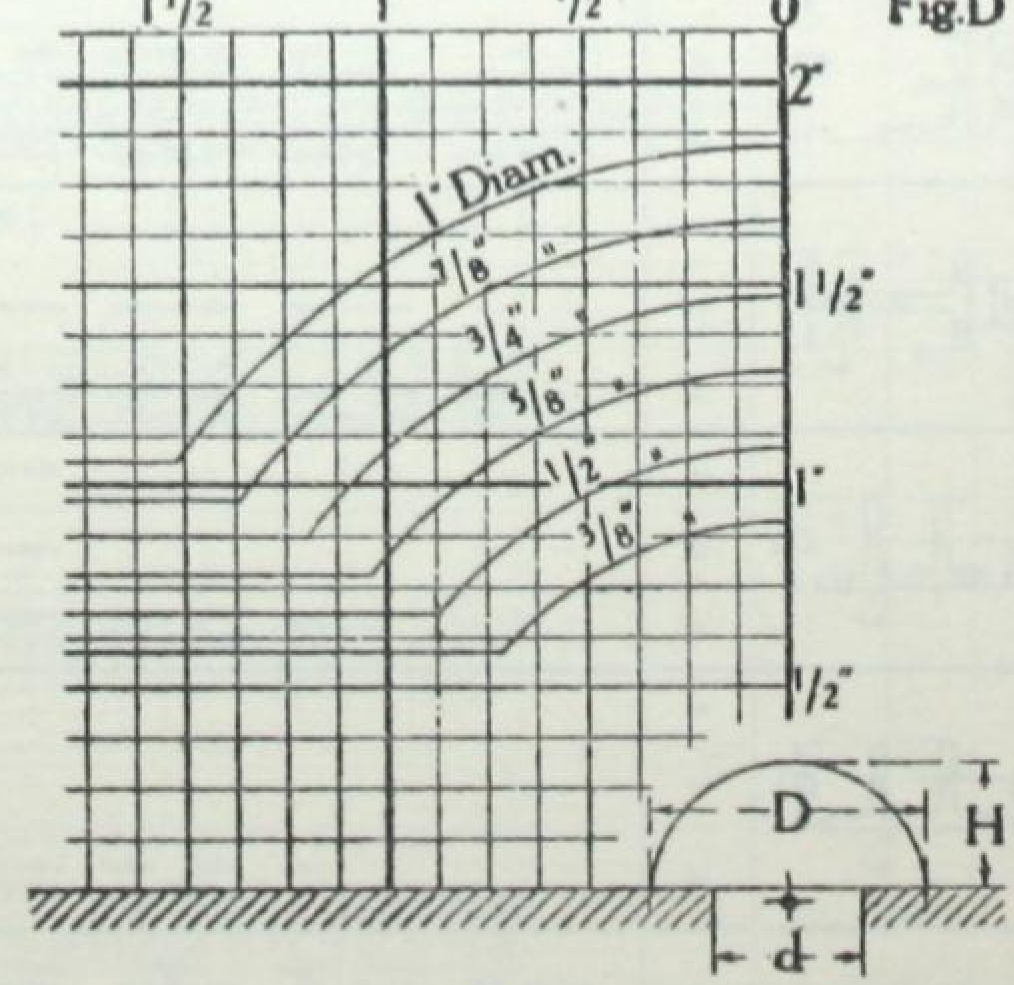
When rivets are used in the same plane through two flanges of an angle or tee as in Fig. C, $\frac{1}{4}''$ clearance, as shewn therein, must be allowed for machine driving.

Fig. C



The diameter of the rivets being known, the lowest permissible value for *x* can be read at a glance from Fig. D below. This diagram is drawn full size, the closest permissible position for the centre of the second rivet being along the circular arcs and straight lines continuing them.

Fig. D



HEXAGON BOLTS AND NUTS.

BRITISH STANDARD DIMENSIONS.

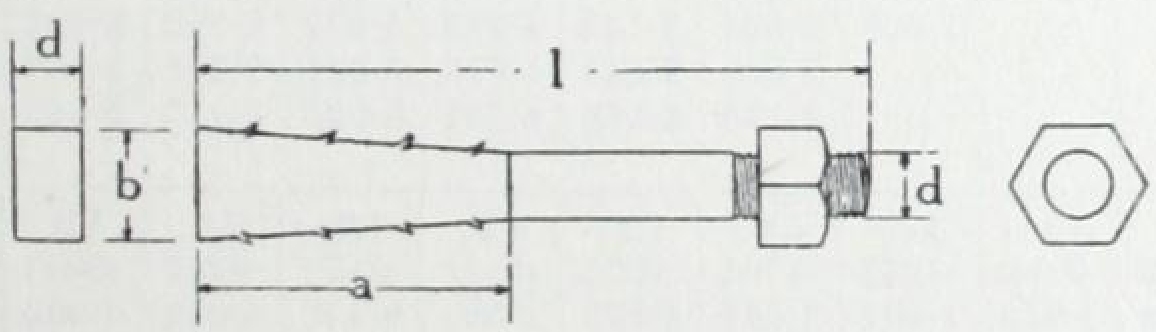
For Weights, see page 214. For safe Shearing and Bearing Loads, see page 208.

Bolt Diameter.	Diameter at bottom of Thread.	Area at bottom of Thread.	Load at $7\frac{1}{2}$ tons Stress.	Number of Threads per inch.	Thickness. Head. Max.	Thickness. Head. Min.	Thickness. Nut. Max.	Thickness. Nut. Min.	Width across Flats. Max.	Width across Flats. Min.	Maximum Width across Corners.	Bolt Diameter.	Area at bottom of Thread.
Ins.	Ins.	Ins.^{2}	Tons.		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.^{2}
$\frac{3}{8}$	·2950	·0683	·512	16	·35	·33	·40	·38	·71	·69	·82	$2\frac{1}{4}$	2·925
$\frac{1}{2}$	·3933	·1215	·911	12	·46	·44	·52	·50	·92	·90	1·06	$2\frac{1}{2}$	3·732
$\frac{5}{8}$	·5086	·2032	1·52	11	·57	·55	·65	·63	1·10	1·08	1·27	$2\frac{3}{4}$	4·464
$\frac{3}{4}$	·6219	·3038	2·28	10	·68	·66	·77	·75	1·30	1·28	1·50	3	5·450
$\frac{7}{8}$	·7327	·4216	3·16	9	·79	·77	·90	·88	1·48	1·46	1·71	$3\frac{1}{4}$	6·406
1	·8399	·5540	4·15	8	·90	·88	1·02	1·00	1·67	1·65	1·93	$3\frac{1}{2}$	7·577
$1\frac{1}{8}$	·9420	·6969	5·23	7	1·01	·98	1·16	1·13	1·86	1·83	2·15	$3\frac{3}{4}$	8·673
$1\frac{1}{4}$	1·0670	·8942	6·71	7	1·12	1·09	1·28	1·25	2·05	2·02	2·37	4	10·03
$1\frac{3}{8}$	1·1616	1·060	7·95	6	1·23	1·20	1·41	1·38	2·22	2·19	2·56	$4\frac{1}{2}$	12·91
$1\frac{1}{2}$	1·2866	1·300	9·75	6	1·34	1·31	1·53	1·50	2·41	2·38	2·78	5	16·15
$1\frac{5}{8}$	1·3689	1·472	11·04	5	1·45	1·42	1·66	1·63	2·58	2·55	2·98	$5\frac{1}{2}$	19·73
$1\frac{3}{4}$	1·4939	1·753	13·15	5	1·56	1·53	1·78	1·75	2·76	2·73	3·19	6	23·65
2	1·7154	2·311	17·33	$4\frac{1}{2}$	1·78	1·75	2·03	2·00	3·15	3·12	3·64	...	...

The dimensions above are those of British Standard Whitworth Black Bolts and Nuts; for further details, including standard sizes of studs, lock nuts and washers, see B.S.S. 28 (1932).

LEWIS BOLTS AND NUTS.

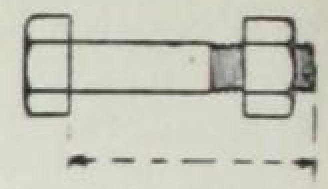
AVERAGE DIMENSIONS AND WEIGHTS.



Dimensions. d	Dimensions. b	Dimensions. a	Dimensions. l	Approximate Weight. Each.	Approximate Weight. Per 1" of Round.
$\frac{3}{4}$"	$1\frac{1}{4}$"	$3\frac{1}{2}$"	$7\frac{1}{2}$"	$1\frac{1}{2}$ lb.	·125 lb.
$\frac{7}{8}$"	$1\frac{3}{8}$"	$3\frac{3}{4}$"	$9\frac{1}{2}$"	$2\frac{3}{8}$,,	·170 ,,
1"	$1\frac{9}{16}$"	4"	$10\frac{1}{2}$"	$3\frac{3}{8}$,,	·222 ,,
$1\frac{1}{8}$"	$1\frac{3}{4}$"	$4\frac{1}{2}$"	12"	$4\frac{3}{4}$,,	·282 ,,
$1\frac{1}{4}$"	2"	$5\frac{1}{2}$"	$13\frac{1}{2}$"	$6\frac{3}{4}$,,	·348 ,,

Roofs, Concrete
Welding.
Plates, Inertia.
Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

WEIGHTS OF HEXAGON BOLTS AND NUTS.



(For Iron, deduct 2%.)

Length (Inches).		WEIGHT OF ONE BOLT AND NUT, IN LB.												
		⅜"	½"	⅝"	¾"	⅞"	1"	1⅛"	1¼"	1⅜"	1½"	1⅝"	1¾"	2"
1	...	·103	·213	...	...	...	...	...	...	...	...	...	...	...
	1⅛	·106	·220	...	...	...	...	...	...	...	...	...	...	...
	1¼	·110	·227	·385	...	...	...	...	...	...	...	...	...	...
	1⅜	·114	·234	·396	...	...	...	...	...	...	...	...	...	...
	1½	·118	·241	·407	·637	...	...	...	...	...	...	...	...	...
	1⅝	·122	·248	·418	·652	...	...	...	...	...	...	...	...	...
	1¾	·126	·255	·429	·668	·989	...	...	...	...	...	...	...	...
	1⅞	·130	·261	·439	·684	1·010	...	...	...	...	...	...	...	...
2	...	·134	·268	·450	·699	1·031	1·440	...	...	...	...	...	...	...
	2¼	·142	·282	·472	·731	1·074	1·496	2·008	...	...	...	...	...	...
	2½	·149	·296	·494	·762	1·116	1·552	2·079	2·722	...	...	...	...	...
	2¾	·157	·310	·515	·793	1·159	1·607	2·149	2·809	3·525	...	...	...	...
3	...	·165	·324	·537	·825	1·202	1·663	2·219	2·896	3·630	4·547	...	...	...
	3¼	·173	·338	·559	·856	1·244	1·719	2·290	2·982	3·736	4·672	5·656	...	...
	3½	·181	·352	·581	·887	1·287	1·774	2·360	3·069	3·841	4·797	5·803	6·992	...
	3¾	·189	·366	·602	·918	1·329	1·830	2·431	3·156	3·946	4·923	5·950	7·162	...
4	...	·196	·380	·624	·950	1·372	1·885	2·501	3·243	4·051	5·048	6·097	7·333	10·426
	4¼	·204	·394	·646	·981	1·415	1·941	2·571	3·330	4·156	5·173	6·244	7·503	10·648
	4½	·212	·408	·668	1·012	1·457	1·997	2·642	3·417	4·261	5·298	6·391	7·674	10·871
	4¾	·220	·421	·689	1·044	1·500	2·052	2·712	3·504	4·367	5·423	6·538	7·844	11·093
5	...	·228	·435	·711	1·075	1·542	2·108	2·783	3·591	4·472	5·548	6·685	8·014	11·316
	5¼	·236	·449	·733	1·106	1·585	2·164	2·853	3·678	4·577	5·674	6·832	8·185	11·538
	5½	·243	·463	·755	1·137	1·627	2·219	2·924	3·765	4·682	5·799	6·979	8·355	11·761
	5¾	·251	·477	·776	1·169	1·670	2·275	2·994	3·852	4·787	5·924	7·125	8·525	11·983
6	...	·259	·491	·798	1·200	1·713	2·331	3·064	3·939	4·893	6·049	7·272	8·696	12·206
	6½	·275	·519	·841	1·263	1·798	2·442	3·205	4·112	5·103	6·299	7·566	9·037	12·651
7	...	·290	·547	·885	1·325	1·883	2·553	3·346	4·286	5·313	6·550	7·860	9·377	13·096
	7½	·306	·574	·928	1·388	1·968	2·664	3·487	4·460	5·524	6·800	8·154	9·718	13·541
8	...	·322	·602	·972	1·450	2·053	2·776	3·628	4·634	5·734	7·050	8·448	10·059	13·986
	8½	...	·630	1·015	1·513	2·139	2·887	3·768	4·808	5·944	7·301	8·741	10·400	14·431
9	...	...	·658	1·059	1·576	2·224	2·998	3·909	4·982	6·155	7·551	9·035	10·740	14·876
	9½	...	...	1·102	1·638	2·309	3·109	4·050	5·156	6·365	7·801	9·329	11·081	15·321
10	...	...	...	1·146	1·701	2·394	3·221	4·191	5·329	6·575	8·052	9·623	11·422	15·766
	10½	...	...	...	1·763	2·479	3·332	4·332	5·503	6·786	8·302	9·917	11·763	16·211
11	...	...	...	...	1·826	2·564	3·443	4·473	5·677	6·996	8·552	10·210	12·103	16·656
	11½	...	...	...	...	2·650	3·554	4·613	5·851	7·206	8·803	10·504	12·444	17·101
12	...	...	...	...	...	2·735	3·666	4·754	6·025	7·417	9·053	10·798	12·785	17·547
		Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
1" of Shank		·0313	·0556	·0869	·1252	·1704	·2225	·2816	·3477	·4207	·5007	·5876	·6815	·8901
1′ 0" of „		·3755	·6676	1·043	1·502	2·044	2·670	3·380	4·172	5·049	6·008	7·051	8·178	10·681
Hex. Nut		·036	·078	·137	·213	·332	·476	·661	·877	1·124	1·428	1·772	2·151	3·195
Add for Sq.		·007	·015	·027	·045	·068	·098	·138	·186	·241	·309	·385	·473	·704
Hex. Nut and Head		·071	·157	·276	·449	·690	·995	1·375	1·852	2·368	3·045	3·747	4·607	6·865
Add for Sq.		·012	·028	·050	·084	·127	·184	·257	·347	·449	·577	·718	·883	1·316

The length is measured from under head to point, as in sketch above.

The weights given for " nut and head " allow for screwing the shank for a length of two diameters.

The weights are calculated for the mean of the dimensions tabulated opposite.

The chamfer angle for the nut and head has been taken as 30° with the face, the interior diameter of the chamfer circle being equal to the width across the flats.

RIVETS AND BOLTS.

PITCH MULTIPLICATION TABLE.

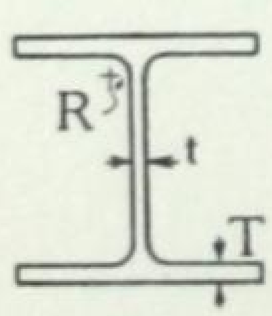
Results given in feet and inches.

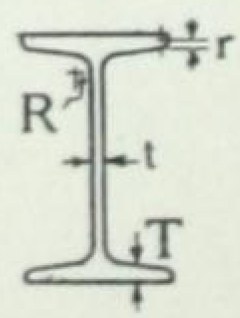
Pitch. (Ins.)	2	3	4	5	6	7	8	9	10	20	30
1-1/8	0 – 2¼	0 – 3⅜	0 – 4½	0 – 5⅝	0 – 6¾	0 – 7⅞	0 – 9	0 –10⅛	0 –11¼	1 –10½	2 – 9¾
1-1/4	0 – 2½	0 – 3¾	0 – 5	0 – 6¼	0 – 7½	0 – 8¾	0 –10	0 –11¼	1 – 0½	2 – 1	3 – 1½
1-3/8	0 – 2¾	0 – 4⅛	0 – 5½	0 – 6⅞	0 – 8¼	0 – 9⅝	0 –11	1 – 0⅜	1 – 1¾	2 – 3½	3 – 5¼
1-1/2	0 – 3	0 – 4½	0 – 6	0 – 7½	0 – 9	0 –10½	1 – 0	1 – 1½	1 – 3	2 – 6	3 – 9
1-5/8	0 – 3¼	0 – 4⅞	0 – 6½	0 – 8⅛	0 – 9¾	0 –11⅜	1 – 1	1 – 2⅝	1 – 4¼	2 – 8½	4 – 0¾
1-3/4	0 – 3½	0 – 5¼	0 – 7	0 – 8¾	0 –10½	1 – 0¼	1 – 2	1 – 3¾	1 – 5½	2 –11	4 – 4½
1-7/8	0 – 3¾	0 – 5⅝	0 – 7½	0 – 9⅜	0 –11¼	1 – 1⅛	1 – 3	1 – 4⅞	1 – 6¾	3 – 1½	4 – 8¼
2	0 – 4	0 – 6	0 – 8	0 –10	1 – 0	1 – 2	1 – 4	1 – 6	1 – 8	3 – 4	5 – 0
2-1/8	0 – 4¼	0 – 6⅜	0 – 8½	0 –10⅝	1 – 0¾	1 – 2⅞	1 – 5	1 – 7⅛	1 – 9¼	3 – 6½	5 – 3¾
2-1/4	0 – 4½	0 – 6¾	0 – 9	0 –11¼	1 – 1½	1 – 3¾	1 – 6	1 – 8¼	1 –10½	3 – 9	5 – 7½
2-3/8	0 – 4¾	0 – 7⅛	0 – 9½	0 –11⅞	1 – 2¼	1 – 4⅝	1 – 7	1 – 9⅜	1 –11¾	3 –11½	5 –11¼
2-1/2	0 – 5	0 – 7½	0 –10	1 – 0½	1 – 3	1 – 5½	1 – 8	1 –10½	2 – 1	4 – 2	6 – 3
2-5/8	0 – 5¼	0 – 7⅞	0 –10½	1 – 1⅛	1 – 3¾	1 – 6⅜	1 – 9	1 –11⅝	2 – 2¼	4 – 4½	6 – 6¾
2-3/4	0 – 5½	0 – 8¼	0 –11	1 – 1¾	1 – 4½	1 – 7¼	1 –10	2 – 0¾	2 – 3½	4 – 7	6 –10½
2-7/8	0 – 5¾	0 – 8⅝	0 –11½	1 – 2⅜	1 – 5¼	1 – 8⅛	1 –11	2 – 1⅞	2 – 4¾	4 – 9½	7 – 2¼
3	0 – 6	0 – 9	1 – 0	1 – 3	1 – 6	1 – 9	2 – 0	2 – 3	2 – 6	5 – 0	7 – 6
3-1/8	0 – 6¼	0 – 9⅜	1 – 0½	1 – 3⅝	1 – 6¾	1 – 9⅞	2 – 1	2 – 4⅛	2 – 7¼	5 – 2½	7 – 9¾
3-1/4	0 – 6½	0 – 9¾	1 – 1	1 – 4¼	1 – 7½	1 –10¾	2 – 2	2 – 5¼	2 – 8½	5 – 5	8 – 1½
3-3/8	0 – 6¾	0 –10⅛	1 – 1½	1 – 4⅞	1 – 8¼	1 –11⅝	2 – 3	2 – 6⅜	2 – 9¾	5 – 7½	8 – 5¼
3-1/2	0 – 7	0 –10½	1 – 2	1 – 5½	1 – 9	2 – 0½	2 – 4	2 – 7½	2 –11	5 –10	8 – 9
3-3/4	0 – 7½	0 –11¼	1 – 3	1 – 6¾	1 –10½	2 – 2¼	2 – 6	2 – 9¾	3 – 1½	6 – 3	9 – 4½
4	0 – 8	1 – 0	1 – 4	1 – 8	2 – 0	2 – 4	2 – 8	3 – 0	3 – 4	6 – 8	10 – 0
4-1/4	0 – 8½	1 – 0¾	1 – 5	1 – 9¼	2 – 1½	2 – 5¾	2 –10	3 – 2¼	3 – 6½	7 – 1	10 – 7½
4-1/2	0 – 9	1 – 1½	1 – 6	1 –10½	2 – 3	2 – 7½	3 – 0	3 – 4½	3 – 9	7 – 6	11 – 3
4-3/4	0 – 9½	1 – 2¼	1 – 7	1 –11¾	2 – 4½	2 – 9¼	3 – 2	3 – 6¾	3 –11½	7 –11	11 –10½
5	0 –10	1 – 3	1 – 8	2 – 1	2 – 6	2 –11	3 – 4	3 – 9	4 – 2	8 – 4	12 – 6
5-1/4	0 –10½	1 – 3¾	1 – 9	2 – 2¼	2 – 7½	3 – 0¾	3 – 6	3 –11¼	4 – 4½	8 – 9	13 – 1½
5-1/2	0 –11	1 – 4½	1 –10	2 – 3½	2 – 9	3 – 2½	3 – 8	4 – 1½	4 – 7	9 – 2	13 – 9
5-3/4	0 –11½	1 – 5¼	1 –11	2 – 4¾	2 –10½	3 – 4¼	3 –10	4 – 3¾	4 – 9½	9 – 7	14 – 4½
6	1 – 0	1 – 6	2 – 0	2 – 6	3 – 0	3 – 6	4 – 0	4 – 6	5 – 0	10 – 0	15 – 0

FILLET RADII ETC.,

OF ROLLED STEEL BEAMS.

Broad Flange Beams	Fillet.	Flange.	Web.	Broad Flange Beams.	Fillet.	Flange.	Web.	British Standard Joists.	Fillet.	Toe.	Flange.	Web.
	R	T	t		R	T	t	d × b	R	r	T	t
	Ins.	Ins.	Ins.		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
4″ DIE	·38	·31	·20	15″ DIE	·83	·75	·43	3 × 1½	·25	·12	·249	·16
4″ DIR	·38	·67	·39	15″ DIR	·83	1·57	·91	3 × 3	·37	·18	·332	·20
5″ DIE	·38	·31	·20	16″ DIE	·83	·79	·43	4 × 1¾	·27	·13	·239	·17
5″ DIR	·38	·67	·39	16″ DIR	·83	1·57	·87	4 × 3	·37	·18	·347	·24
5½″ DIE	·47	·33	·22	17″ DIE	·83	·83	·45	4¾ × 1¾	·27	·13	·325	·18
5½″ DIR	·47	·94	·63	17″ DIR	·83	1·57	·87	5 × 3	·37	·18	·376	·22
6″ DIE	·47	·33	·22	18″ DIE	·89	·87	·47	5 × 4½	·49	·24	·513	·29
6″ DIR	·47	·94	·63	18″ DIR	·89	1·57	·83	6 × 3	·37	·18	·377	·23
6¼″ DIE	·53	·35	·24	19″ DIE	·89	·91	·49	6 × 4½	·49	·24	·431	·37
6¼″ DIR	·53	·98	·63	19″ DIR	·89	1·57	·83	6 × 5	·53	·26	·520	·41
7″ DIE	·53	·39	·26	20″ DIE	·94	·94	·51	7 × 4	·45	·22	·387	·25
7″ DIR	·53	·98	·63	20″ DIR	·94	1·57	·83	8 × 4	·45	·22	·398	·28
8″ DIE	·59	·43	·28	22″ DIE	·94	·96	·51	8 × 5	·53	·26	·575	·35
8″ DIR	·59	1·02	·63	22″ DIR	·94	1·57	·83	8 × 6	·61	·30	·648	·35
8½″ DIE	·59	·45	·29	24″ DIE	1·00	1·02	·55	9 × 4	·45	·22	·457	·30
8½″ DIR	·59	1·02	·63	24″ DIR	1·00	1·57	·83	9 × 7	·69	·34	·825	·40
9½″ DIE	·65	·49	·31	26″ DIE	1·00	1·02	·55	10 × 4½	·49	·24	·505	·30
9½″ DIR	·65	1·10	·67	26″ DIR	1·00	1·57	·83	10 × 5	·53	·26	·552	·36
10″ DIE	·65	·51	·31	28″ DIE	1·06	1·10	·59	10 × 6	·61	·30	·709	·36
10″ DIR	·65	1·18	·71	28″ DIR	1·06	1·57	·83	10 × 8	·77	·38	·783	·40
10¼″ DIE	·65	·51	·31	30″ DIE	1·06	1·10	·59	12 × 5	·53	·26	·550	·35
10¼″ DIR	·65	1·26	·79	30″ DIR	1·06	1·57	·83	12 × 6	·61	·30	·717	·40
11″ DIE	·71	·53	·32	32″ DIE	1·06	1·18	·63	12 × 6	·61	·30	·883	·50
11″ DIR	·71	1·38	·83	32″ DIR	1·06	1·57	·83	12 × 8	·77	·38	·904	·43
12″ DIE	·71	·57	·34	34″ DIE	1·12	1·26	·67	13 × 5	·53	·26	·604	·35
12″ DIR	·71	1·50	·91	34″ DIR	1·12	1·57	·83	14 × 6	·61	·30	·698	·40
12½″ DIE	·77	·63	·37	36″ DIE	1·12	1·26	·67	14 × 6	·61	·30	·873	·50
12½″ DIR	·77	1·57	·91	36″ DIR	1·12	1·57	·83	14 × 8	·77	·38	·920	·46
13½″ DIE	·77	·67	·39	38″ DIE	1·12	1·26	·67	15 × 5	·53	·26	·647	·42
13½″ DIR	·77	1·57	·91	38″ DIR	1·12	1·57	·83	15 × 6	·61	·30	·655	·38
14″ DIE	·83	·71	·41	40″ DIE	1·12	1·26	·67	16 × 6	·61	·30	·726	·40
14″ DIR	·83	1·57	·91	40″ DIR	1·12	1·57	·83	16 × 6	·61	·30	·847	·55
								16 × 8	·77	·38	·938	·48
								18 × 6	·61	·30	·757	·42
								18 × 7	·69	·34	·928	·55
								18 × 8	·77	·38	·950	·50
								20 × 6½	·65	·32	·820	·45
								20 × 7½	·73	·36	1·01	·60
								22 × 7	·69	·34	·834	·50
								24 × 7½	·73	·36	1·01	·57





In the above table, all standard sections of Broad Flange Beams are listed, but only their DIE (minimum) and DIR (maximum) weights. In all cases the *fillet radius* is 1½ times the web thickness of the DIN (medium) weight.

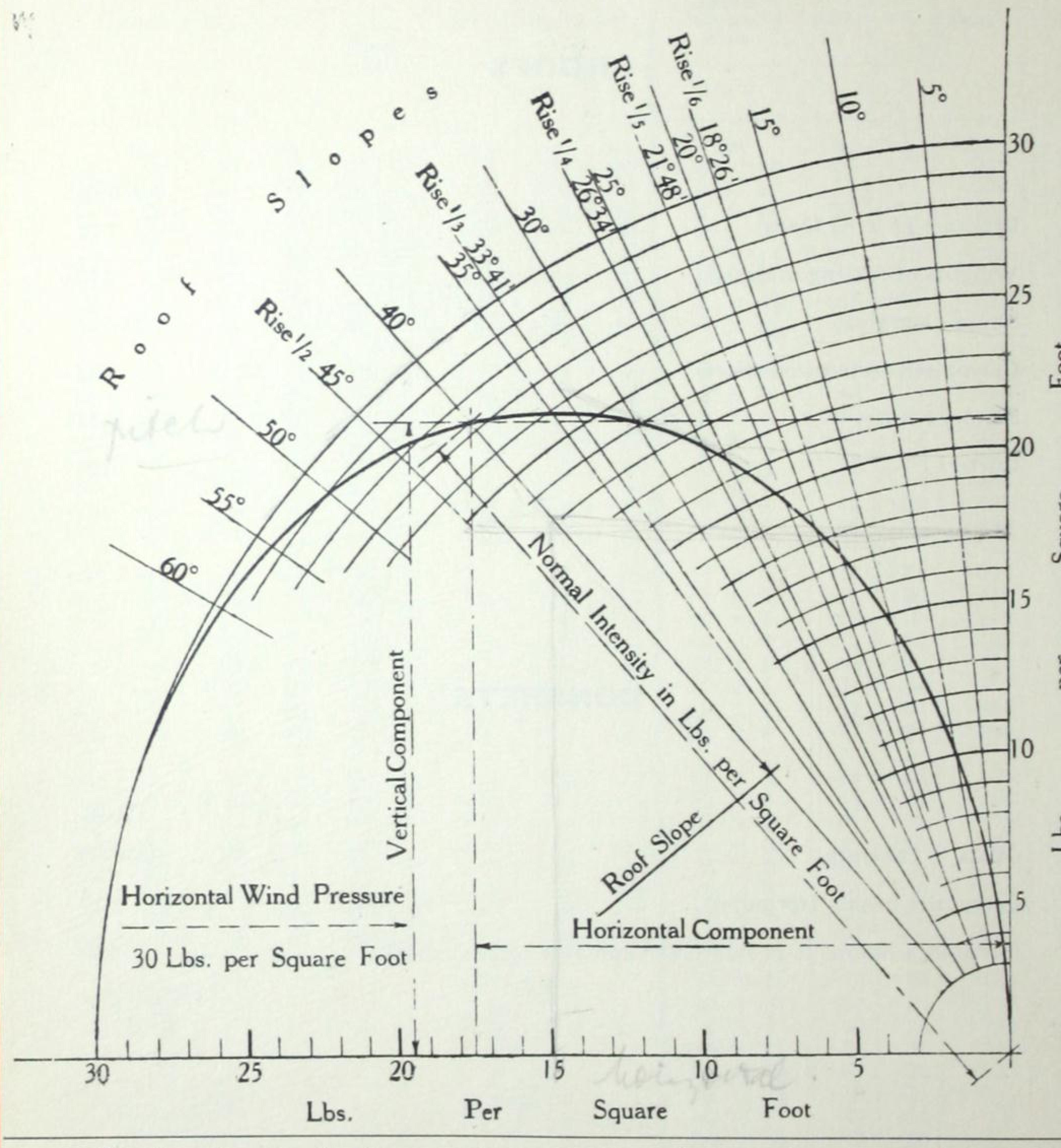
The flanges of British Standard Joists have a *taper* of 98°, namely 1: 7 approx. B. F. Beams, Grey Process, have no flange taper.

ROOFS

CONCRETE

WIND LOADS ON ROOFS

OR OTHER SLOPING SURFACES.



The above diagram gives the normal component on a sloping surface, due to a horizontal wind pressure of 30 lb. per square foot reduced in accordance with Duchemin's formula :—

Normal Pressure = Horizontal Pressure × 2 Sin a ÷ (1 + Sin² a) where Sin a is the ratio of rise to length of slope.

The vertical and horizontal components of this normal pressure can be scaled from the diagram.

The pressure in lb. per square foot = Square of Wind Velocity in miles per hour, approx. × ·0032.

WEIGHTS OF ROOFING MATERIALS.

(Approximate).

Material.	Lb. per sq. ft.	Material.	Lb. per sq. ft.
Asbestos-cement sheets :		Lead Sheeting, $\frac{1}{16}''$ thick	7
Corrugated, $\frac{1}{4}''$ thick, with laps ...	$3\frac{1}{4}$	,, ,, with lap and rolls ...	9
Flat, butted joints, $\frac{1}{4}''$ thick ...	$2\frac{1}{4}$	Plaster ceiling, per 1″ thick ...	9 to 12
Asphalt, per 1″ thick	11 to 12	,, Lathing for	$1\frac{1}{4}$
Bituminous Felt :			
Single-ply, without lap	$\frac{1}{4}$	Plywood, per $\frac{1}{4}''$ thick	$\frac{7}{8}$
Two-ply ,, ,, ...	$\frac{3}{8}$	Slates, 3″ lap, with nails	$8\frac{1}{2}$
Three-ply ,, ,, ...	$\frac{1}{2}$	,, Wood purlins for	$2\frac{3}{4}$
Boarding, per 1″ actual	$2\frac{1}{4}$ to 3	Snow, Allowance for	5
Copper sheeting, 24 gauge	$1\frac{1}{4}$	Steel, corrugated sheet, 18 gauge ...	$2\frac{3}{4}$
		,, Purlins for	$1\frac{3}{4}$
Glass, without laps, $\frac{1}{4}''$ thick ...	3		
Glazing Bars, sheathed steel ...	$1\frac{1}{2}$ to $2\frac{1}{2}$	Tiles, Pan	$7\frac{1}{2}$ to 10
,, Purlins	2	,, Plain	$12\frac{1}{2}$ to 18
Insulating Pulp board, $\frac{1}{2}''$ thick ...	$\frac{2}{3}$ to $\frac{3}{4}$	Zinc sheeting, 0·04″ thick	$1\frac{3}{4}$

The above are the rough estimated weights per square foot of roof surface, *i.e.*, measured on the slope if sloping. For wind loads, see page 218. For weights of various other substances, see pages 306–307.

WEIGHT OF TRUSS. This will usually not exceed 1 lb. per square foot of actual roof surface for each 10 feet of span, *i.e.*, 3 lb. per square foot for a 30′ 0″ span, and so on. The assumed weight should be verified after design.

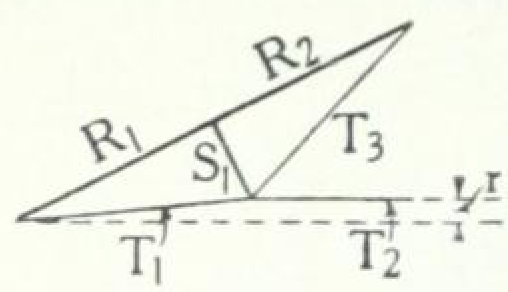
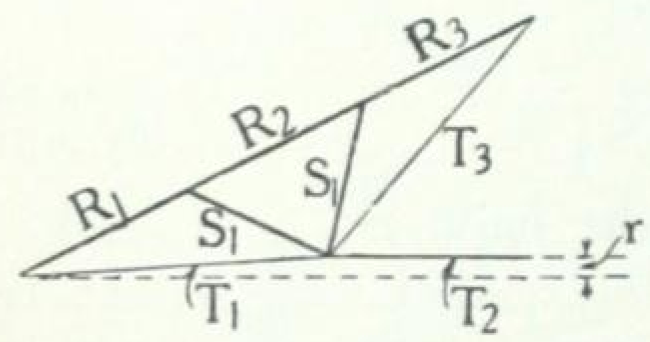
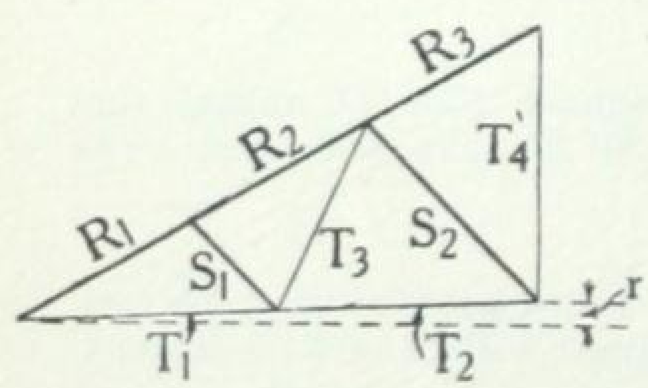
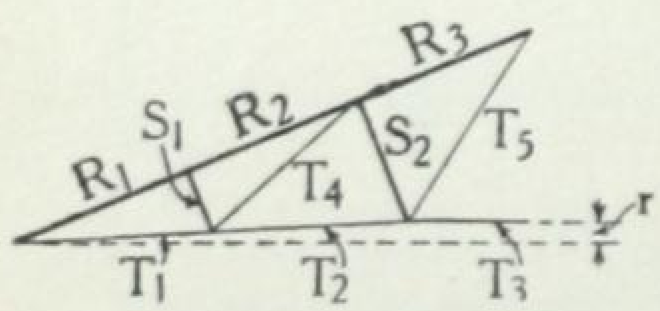
ROOF DRAINAGE. British practice is to place down pipes at centres not greater than 20 feet, and to provide an internal area not less than 1 square inch per 60 square feet of surface drained.

Gutters should have a width not less than twice the internal diameter of the down pipes and a fall of about $\frac{1}{16}''$ in n feet, where n is the gutter width in inches. For pressed steel gutters, see page 224.

ANGLES AND TEES. For their weights per foot, and for the safe loads of angles as struts, see separate chapter hereon, pages 191–205.

STANDARD TYPES OF ROOF TRUSSES.

TABLE OF COEFFICIENTS FOR STRESSES AND LENGTHS.

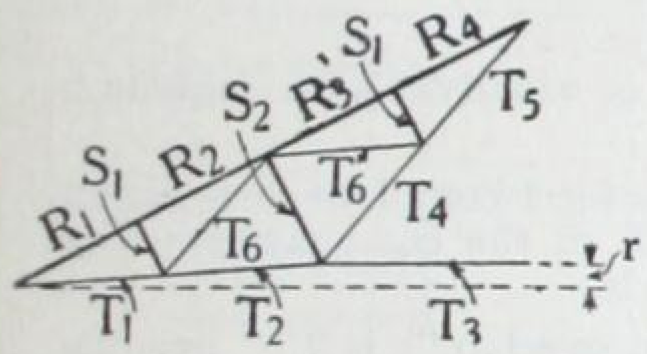
TYPE. (Diagrams shew half spans.)	Member.	Rise=1/3 Span.			Rise=30°.			Rise=1/4 Span.			Rise=1/5 Span		
		Stresses.		Length.	Stresses.		Length.	Stresses.		Length.	Stresses.		Length.
		Dead Load	Wind Load		Dead Load	Wind Load		Dead Load	Wind Load		Dead Load	Wind Load	
	R_1	·79	·72	·300	·91	·91	·289	1·01	1·08	·280	1·23	1·42	·270
	R_2	·66	·72	·300	·79	·91	·289	·90	1·08	·280	1·14	1·42	·270
	T_1	·66	·74	·340	·79	·92	·315	·91	1·08	·300	1·15	1·42	·282
	T_2	·41	·19	·322	·49	·28	·371	·56	·37	·400	·69	·55	·440
	T_3	·27	·55	·340	·33	·65	·315	·37	·72	·300	·47	·88	·282
	S_1	·21	·50	·160	·22	·50	·130	·22	·50	·112	·23	·50	·086
	R_1	·88	·87	·200	1·01	1·10	·193	1·12	1·28	·186	1·37	1·68	·180
	R_2	·70	·67	·200	·82	·85	·193	·92	1·01	·186	1·15	1·33	·180
	R_3	·70	·87	·200	·84	1·10	·193	·98	1·28	·186	1·24	1·68	·180
	T_1	·74	·92	·340	·88	1·12	·315	1·01	1·30	·300	1·27	1·69	·282
	T_2	·41	·19	·322	·49	·28	·371	·56	·37	·400	·69	·55	·436
	T_3	·34	·74	·340	·42	·85	·315	·47	·94	·300	·60	1·15	·282
	S_1	·16	·39	·188	·18	·42	·161	·20	·43	·145	·22	·48	·126
	R_1	·84	·82	·200	·94	1·00	·193	—	—	—	—	—	—
	R_2	·73	·77	·200	·82	·91	·193	—	—	—	—	—	—
	R_3	·50	·57	·200	·56	·62	·193	—	—	—	—	—	—
	T_1	·70	·87	·251	·82	1·04	·251	—	—	—	—	—	—
	T_2	·56	·53	·251	·65	·66	·251	—	—	—	—	—	—
	T_3	·12	·30	·222	·13	·29	·194	—	—	—	—	—	—
	T_4	·39	·44	·302	·40	·43	·255	—	—	—	—	—	—
	S_1	·14	·34	·126	·15	·35	·115	—	—	—	—	—	—
	S_2	·21	·51	·252	·22	·52	·230	—	—	—	—	—	—
	R_1	—	—	—	—	—	—	1·06	1·21	·186	1·29	1·59	·180
	R_2	—	—	—	—	—	—	·99	1·21	·186	1·23	1·59	·180
	R_3	—	—	—	—	—	—	·74	·82	·186	·94	1·10	·180
	T_1	—	—	—	—	—	—	·95	1·23	·203	1·20	1·60	·190
	T_2	—	—	—	—	—	—	·76	·81	·203	·96	1·09	·190
	T_3	—	—	—	—	—	—	·56	·37	·192	·69	·54	·242
	T_4	—	—	—	—	—	—	·19	·42	·203	·24	·52	·190
	T_5	—	—	—	—	—	—	·26	·54	·243	·24	·63	·217
	S_1	—	—	—	—	—	—	·15	·33	·079	·15	·33	·061
	S_2	—	—	—	—	—	—	·22	·50	·158	·23	·50	·121
Rise of Tie	r	1/30th of Span			1/30th of Span			1/40th of Span			1/50th of Span		

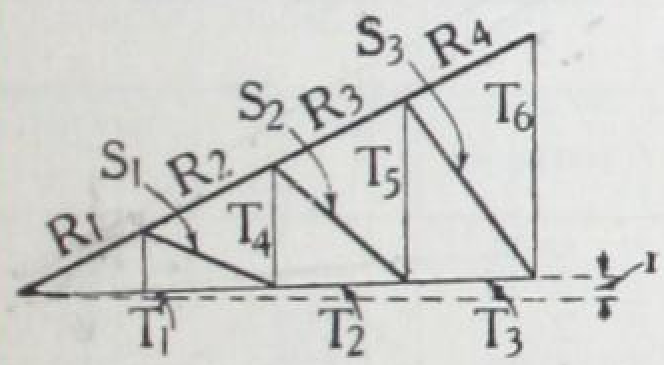
For Notes, see opposite page.

STANDARD TYPES OF ROOF TRUSSES.

TABLE OF COEFFICIENTS FOR STRESSES AND LENGTHS.—Continued.

TYPE.
(Diagrams shew half spans.)





Member	Rise = 1/3 Span. Stresses. Dead Load	Wind Load	Length.	Rise = 30°. Stresses. Dead Load	Wind Load	Length.	Rise = 1/4 Span. Stresses. Dead Load	Wind Load	Length.	Rise = 1/5 Span. Stresses. Dead Load	Wind Load	Length.
R_1	·93	·95	·150	1·08	1·21	·144	1·18	1·39	·140	1·44	1·81	·135
R_2	·86	·95	·150	1·01	1·21	·144	1·13	1·39	·140	1·39	1·81	·135
R_3	·79	·95	·150	·95	1·21	·144	1·07	1·39	·140	1·34	1·81	·135
R_4	·72	·95	·150	·89	1·21	·144	1·01	1·39	·140	1·30	1·81	·135
T_1	·77	1·00	·170	·94	1·22	·157	1·06	1·41	·150	1·34	1·83	·141
T_2	·66	·74	·170	·80	·92	·157	·91	1·08	·150	1·15	1·41	·141
T_3	·41	·19	·322	·49	·28	·371	·56	·37	·400	·69	·55	·436
T_4	·27	·56	·170	·34	·65	·157	·37	·72	·150	·47	·88	·141
T_5	·38	·82	·170	·47	·95	·157	·52	1·05	·150	·66	·29	·141
T_6	·11	·27	·170	·14	·31	·157	·15	·33	·150	·19	·41	·141
S_1	·10	·25	·080	·11	·25	·065	·11	·25	·056	·12	·25	·043
S_2	·21	·50	·160	·22	·50	·130	·22	·50	·112	·23	·50	086
R_1	·88	·89	·150	·99	1·10	·144	1·09	1·27	·140	1·31	1·64	·135
R_2	·76	·75	·150	·85	·91	·144	·94	1·05	·140	1·12	1·34	·135
R_3	·63	·62	·150	·71	·73	·144	·78	·83	·140	·93	1·04	·135
R_4	·51	·57	·150	·57	·62	·144	·62	·67	·140	·75	·73	·135
T_1	·74	·95	·251	·86	1·14	·251	·98	1·31	·250	1·21	1·66	·250
T_2	·63	·70	·125	·74	·86	·125	·84	1·00	·125	1·04	1·29	·125
T_3	·53	·45	·125	·62	·57	·125	·70	·69	·125	·87	·92	·125
T_4	·06	·15	·150	·06	·15	·128	·06	·14	·113	·06	·14	·090
T_5	·13	·30	·225	·13	·29	·192	·12	·28	·169	·13	·27	·135
T_6	·43	·48	·300	·44	·47	·256	·43	·46	·225	·43	·45	·180
S_1	·12	·28	·142	·13	·31	·137	·15	·34	·135	·18	·39	·131
S_2	·16	·38	·189	·17	·39	·173	·18	·41	·164	·21	·45	·150
S_3	·21	·50	·250	·22	·50	·223	·23	·51	·202	·25	·54	·180
Rise of Tie r	1/30th of Span			1/30th of Span			1/40th of Span			1/50th of Span		

STRESSES. To obtain the stress in a member due to dead load, multiply the total dead load on the truss by the tabulated " dead load " coefficient.

To obtain the maximum stress in a member due to wind, multiply the total normal component of the wind load on one-half of the truss by the tabulated " wind load " coefficient. [The normal components can be read from the chart on page 218.]

The wind coefficients have been calculated on the assumption that the horizontal components of the end reactions are equal.

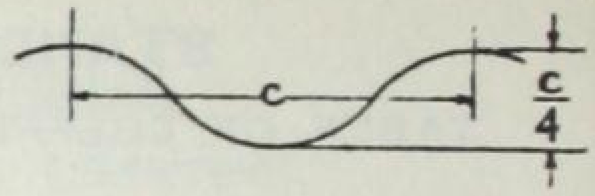
Members marked R and S are in compression ; those marked T are in tension.

LENGTHS. To obtain the length of a member, multiply the total span by the tabulated " length " coefficient.

LONDON BUILDINGS AND B.S.S. 449. In the L.C.C. By-Laws (1937), and B.S.S. 449, the wind load to be provided for is 15 lb. per square foot on the windward side and 10 lb. suction on the leeward side. The foregoing coefficients can readily be adapted to these conditions.

Welding. Plates, Inertia. Tests, Extras. Weights, Measures. Math. tables. Index, Code.

GALVANISED CORRUGATED SHEETS.



NOTES.

1. **Gauge.** The thickness is generally expressed in Birmingham gauge, and is understood to refer to the thickness before galvanising. The thicknesses obtainable range from 12 to 30 B.G. The thickness most commonly used is 24 B.G.; but for first-class roofwork 18 and 20 B.G. are commonly specified.

2. **Stocks.** The sheets most commonly stocked are of lengths 5, 6, 7, 8, 9 and 10 ft.; width 8/3″ corrugations; thicknesses 20, 22, 24 and 26 B.G.

3. **Corrugations.** The commonest pitch (*c* in above sketch) is 3″ and the depth usually one-fourth of this; 16 and 18 B.G. sheets are usually made with 5″ corrugations; 4″ and other corrugations are also made. For corrugations of the proportions shewn in the sketch, the area of the sheet before corrugation is 1·16 times the area covered.

4. **Spelter.** In first-class work the amount of zinc called for is usually 2¼ oz. minimum per sq. ft. There are also chemical tests.

5. **Strength.** With the configuration shewn, the section modulus for 1 complete corrugation is $\cdot 077\ c^2t$, where t is the thickness in inches and c is the length of the corrugation. The breaking stress may be taken as about 18 to 20 tons per square inch.

6. **Side Overlap.** The minimum side overlap ("one corrugation overlap") is 2″. For one complete corrugation overlap ("two corrugations overlap"), it is 5″.

7. **End Overlap.** In a roof, this should not be less than 6″, but in vertical work it may be 3″.

8. **Rivets and Bolts.** Rivets will weigh about 3 lb. per 100 feet super; hook bolts and washers about 4 lb. For details, see opposite page.

9. **Galvanised Fittings.** See opposite page.

WEIGHTS AND AREAS.—APPROXIMATE.

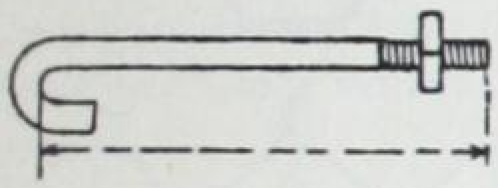
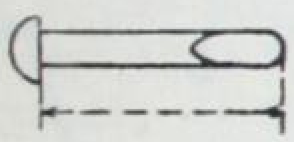
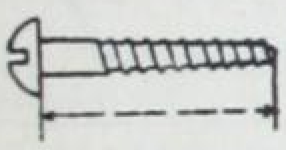
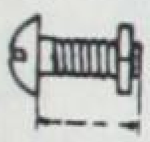
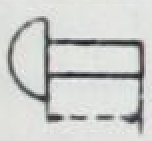
Gauge. (B.G.)		Corrugations.	Width.		Weight per			Sq. yards per ton.	Feet run per ton.
No.	Ins.		Overall.	Nett.	Sq. yard.	Foot run.	100 sq. ft.		
					Lb.	Lb.	Cwts.		
16	·062	5/5″	2′ 3″	2′ 0″	29·5	6·67	2·48	76	336
18	·049	8/3″	2′ 2″	2′ 0″	21·9	4·86	2·17	102	461
20	·039	,,	,,	,,	17·7	3·93	1·75	127	570
22	·031	,,	,,	,,	14·8	3·29	1·47	152	681
24	·025	,,	,,	,,	12·0	2·67	1·19	187	839
26	·020	,,	,,	,,	9·27	2·06	0·92	242	1087
28	·016	,,	,,	,,	7·51	1·66	0·74	299	1344

NUMBER OF SHEETS PER TON.—APPROXIMATE.

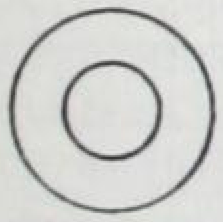
Gauge. (B.G.)		8/3″ Corrugations.						10/3″ Corrugations.					
No.	Ins.	5′ 0″	6′ 0″	7′ 0″	8′ 0″	9′ 0″	10′ 0″	5′ 0″	6′ 0″	7′ 0″	8′ 0″	9′ 0″	10′ 0″
18	·049	92	76	65	57	51	46	74	62	53	46	41	37
20	·039	115	96	82	72	64	57	95	79	68	59	53	47
22	·031	135	113	97	85	76	68	116	97	83	73	65	58
24	·025	168	140	120	105	93	84	140	117	100	88	78	70
26	·020	218	182	156	137	122	109	186	155	133	116	103	93
28	·016	240	200	172	150	...	...	200	167	143	125	...	...

SUNDRY FITTINGS.

GALVANISED BOLTS, ETC.

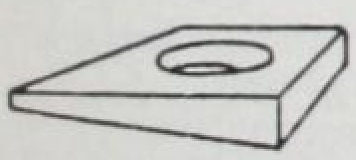
			Approx. weights galvanised Per gross.	Per 100.
	HOOK BOLTS.	$\frac{5}{16}''$ dia. × $3\frac{1}{2}''$ long ,, ,, × $4''$,, ,, ,, × $4\frac{1}{2}''$,, ,, ,, × $5''$,, $\frac{3}{8}''$,, × $3\frac{1}{2}''$,, ,, ,, × $4''$,, ,, ,, × $4\frac{1}{2}''$,, ,, ,, × $5''$,,	$18\frac{3}{4}$ lb. $20\frac{3}{4}$,, $22\frac{3}{4}$,, $24\frac{3}{4}$,, 25 ,, 29 ,, 33 ,, 37 ,,	13 lb. $14\frac{1}{2}$,, $15\frac{3}{4}$,, $17\frac{1}{4}$,, $17\frac{1}{2}$,, $20\frac{1}{4}$,, 23 ,, $25\frac{3}{4}$,,
	ROOFING NAILS.	$\frac{1}{4}''$ dia. × $2\frac{1}{2}''$ long ,, ,, × $3''$,,	5 lb. 6 ,,	$3\frac{1}{2}$ lb. $4\frac{1}{4}$,,
	ROOFING SCREWS.	$\frac{1}{4}''$ dia. × $2\frac{1}{2}''$ long ,, ,, × $3''$,,	$5\frac{3}{4}$ lb. 7 ,,	4 lb. $4\frac{3}{4}$,,
	SHEETING BOLTS & NUTS.	$\frac{1}{4}''$ dia. × $\frac{3}{4}''$ long ,, ,, × $1\frac{1}{4}''$,, ,, ,, × $1\frac{1}{2}''$,,	$3\frac{5}{8}$ lb. $4\frac{5}{8}$,, $5\frac{1}{8}$,,	$2\frac{1}{2}$ lb. $3\frac{1}{4}$,, $3\frac{1}{2}$,,
	SHEETING RIVETS.	$\frac{1}{4}''$ dia. × $\frac{3}{8}''$ long ,, ,, × $\frac{1}{2}''$,, ,, ,, × $\frac{5}{8}''$,,	$1\frac{3}{4}$ lb. 2 ,, $2\frac{1}{4}$,,	$1\frac{1}{4}$ lb. $1\frac{1}{2}$,, $1\frac{1}{2}$,,
	WASHERS FOR 1/4″ BOLTS, ETC.	Diamond Curved Flat Circular Limpet	$6\frac{1}{4}$ lb. 2 ,, $1\frac{1}{2}$,,	$4\frac{1}{2}$ lb. $1\frac{1}{2}$,, 1 ,,

FLAT WASHERS.



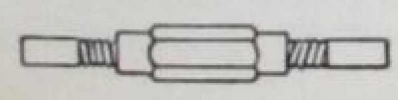
Bolt Diameter.	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$	$1\frac{1}{8}''$	$1\frac{1}{4}''$	$1\frac{3}{8}''$	$1\frac{1}{2}''$
Washer Diameter (Ins.)	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{3}{8}$	$2\frac{5}{8}$	$2\frac{7}{8}$	$3\frac{1}{8}$
,, Thickness (Ins.)	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$
Weight per 100 (Lb.)	$2\frac{1}{2}$	4	$5\frac{1}{2}$	$7\frac{1}{2}$	14	$17\frac{1}{2}$	$21\frac{1}{2}$	26	$30\frac{1}{2}$

BEVEL WASHERS.



Bolt Diameter.	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
Size of Square (Ins.)	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{7}{8}$	$2\frac{1}{8}$
Mean Thickness (Ins.)	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$
Weight per 100 (Lb.)	$5\frac{1}{2}$	$8\frac{1}{4}$	$10\frac{1}{4}$	15	$19\frac{1}{2}$

HEXAGON COUPLING BOXES AND STUB ENDS.

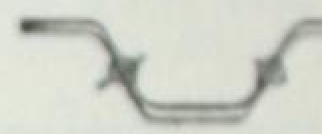


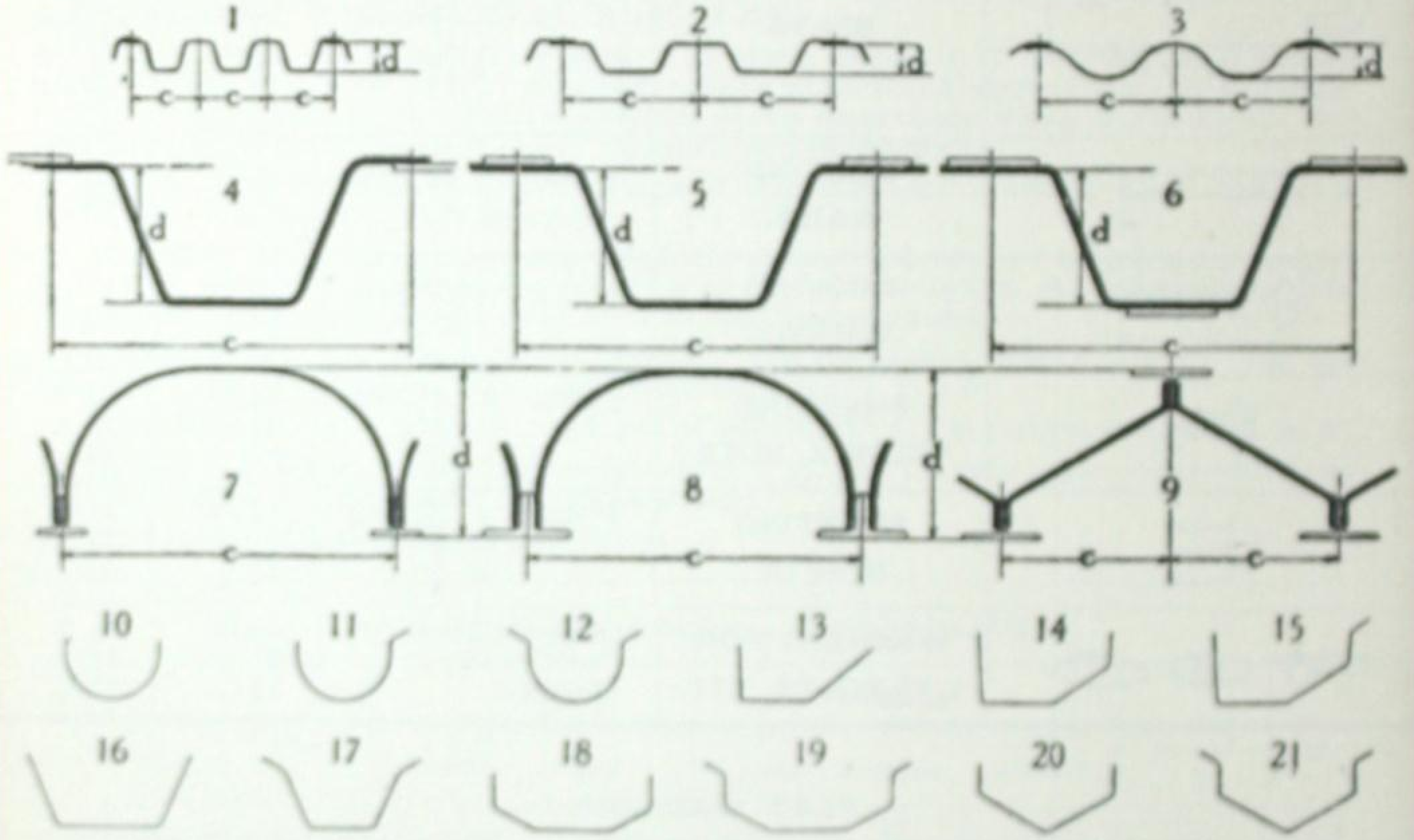
Diameter.	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$	$1\frac{1}{8}''$	$1\frac{1}{4}''$	$1\frac{3}{8}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$
Length of Box (Ins.)	5	6	7	$7\frac{1}{2}$	8	8	8	9	9
,, ,, Ends (Ins.)	12	12	12	12	12	12	12	12	12

Welding.
Plates, Inertia.
Tests, Extras.
Weights, Measures.
Math. tables.
Index, Code.

PRESSED STEEL TROUGHING AND GUTTERS.

The following are diagrammatic sections of the commoner types of pressed steel troughing and gutters. They are pressed from steel plates, so that the thickness is necessarily uniform throughout the section. But a few sections similar to type 4 are also *rolled* in this country and in the United States; these are not necessarily of uniform thickness and are usually riveted together thus :—





COMMON TROUGHING SECTIONS : TYPES 1 TO 5.

Type No.	Corrugations (c).	Overlap.	Mean Depth (d).	Thickness.	Joint Plate.
1	6"	$1\frac{1}{2}$"	$2\frac{1}{4}$", $2\frac{3}{4}$", 3"	$\frac{1}{16}$" to $\frac{1}{8}$"	...
2	12", 15", 16"	$2\frac{1}{2}$" and 3"	3", 4", 5"	$\frac{1}{8}$" to $\frac{1}{4}$"	...
3	12"	$2\frac{1}{2}$" and 3"	3"	$\frac{1}{8}$" to $\frac{1}{4}$"	...
4	20", 24", 30", 32", 34"	$2\frac{1}{2}$" and 3"	6", $7\frac{1}{2}$", 9", 10", 12", 14"	$\frac{1}{4}$" to $\frac{1}{2}$"	...
5	24", 30", 32", 34", 36"	...	$7\frac{1}{2}$", 10", 12", 14", 15", 16"	$\frac{1}{4}$" to $\frac{1}{2}$"	6" or 8"

These Types can be cambered to save dead load in bridge construction.

TYPE 6 : Troughing as in Fig. 5, but reinforced by a plate riveted to the bottom ; the plates are usually $\frac{1}{8}$" thicker than the troughing.

TYPES 7 TO 9 : Hobson's Sections of tees and plates $\frac{1}{4}$" to $\frac{1}{2}$" thick ; or with pairs of angles for $\frac{1}{2}$" plates. Normal dimensions for Types 7 and 8 are :—Centres (c), 21", $22\frac{1}{2}$", 27" and 30" ; overall depth (d), 9", $9\frac{1}{2}$", 10", 12" and 15". Normal dimensions for Type 9 are :—Tees, 5" × 3" × $\frac{1}{2}$" and 6" × 3" × $\frac{1}{2}$"; centres (c), 15" ; overall depth (d), $12\frac{1}{2}$", 14", 15" and 16".

TYPES 10 TO 15 : Eaves Gutters, usually $\frac{1}{8}$" to $\frac{1}{4}$" thick.

TYPES 16 TO 21 : Box and Valley Gutters, usually $\frac{1}{8}$" to $\frac{1}{4}$" thick.

STEEL BEAMS IN CONCRETE.

1. TABLES.

The Tables below will be found useful for determining the appropriate section and spacing of " filler " joists embedded in concrete. The procedure is to ascertain the Bending Moment from Table A and then to select from Table B one or other of the arrangements which provide a corresponding Moment of Resistance.*

2. EXAMPLE.

A factory floor is to be constructed with concrete and R.S. Joists supported on main girders spaced 11 feet apart, centre to centre, to take a superimposed load of 150 lb. per square foot. If the thickness of the concrete has not already been determined, the dead weight must be provisionally estimated, with due allowance for floor finish and ceiling. Table C may assist in this. Supposing it to be 74 lb. per square foot, then the *total* floor load will be $150 + 74 = 224$ lb. per square foot.

Taking the span of the filler joists as equal to the spacing of the main girders, namely 11 feet†, reference to Table A shews that the corresponding Bending Moment (per foot of width) is 18·1 ton-inches.

Now, turning to Table B we find that we could use $5'' \times 3''$ joists with 1″ top cover at 3′ 6″ centres, and that there are various other possible arrangements which will give the required moment of resistance—*e.g.*, $4\frac{3}{4}'' \times 1\frac{3}{4}''$ joists with 2″ top cover at 2′ 5″ centres.

To accord with the recommendations of British Standard Specification 449 (§ 14), the span of the flooring must not exceed the maxima given in Table B.

3. ALTERNATIVE LOADS.

The ordinary allowance for floor loads may not make adequate provision for concentrated or unequal loading. In order to provide for such conditions, British Standard Specification 449 (§ 8*a*) and the London By-laws (§ 4) prescribe that beams and slabs respectively must be capable of carrying alternatively (*i.e.*, with an otherwise unloaded floor) the superimposed loads tabulated in column B on page 280.

Thus, in the example cited above, each reinforced filler joist (or where the spacing is 3′ or less, each *pair* of joists) must be capable of bearing a superimposed distributed load of 2 tons. With $5'' \times 3''$ joists of 11′ span at 3′ 6″ centres, this is equivalent to $4{,}480 \div (11 \times 3\cdot5) = 117$ lb. per sq. foot. With $4\frac{3}{4}''$ joists at 2′ 5″ centres, a distributed load of 1 ton per joist (2 tons per pair) is equivalent to 85 lb. per sq. ft. In either case, as we have assumed a superimposed load of 150 lb. per sq. ft., the alternative loading is amply provided for.

Regarding the whole flooring system from main girder to main girder as a " slab," it must be capable of sustaining a superimposed load of $\frac{3}{8}$ ton (840 lb.) per foot of width ; and we have in fact provided for a superimposed load of $11 \times 150 = 1{,}650$ lb. per foot of width.

* It will be seen that in Table B the Resistance Moments are calculated for each joist section for a cover of one inch and two inches of concrete, respectively. The Resistance Moments for the same R.S. Joists with either more or less cover of concrete can readily be ascertained by extrapolation, with sufficient accuracy for practical purposes ; the error will be on the safe side.

† If the main girders are Broad Flange Beams with 12″ flanges, the effective span of the joists can usually be taken as 6″ less than the spacing of the main girders.

STEEL BEAMS IN CONCRETE.—Continued.

4. MAXIMUM SPACING.

To avoid excessive tensile stress in the concrete between the joists, the ratio of span to depth—*i.e.*, the ratio of the spacing of the joists to the thickness of the concrete—must not exceed the following unless the concrete between the joists is reinforced (*e.g.*, by expanded metal) or the joists prevented, by tie-rods or otherwise, from spreading :—

Floor load, per square foot	100	112	150	168	200	224	250	280	300 lb.
Max. ratio of span to depth	7·6 to 10·7	7·2 to 10·1	6·2 to 8·8	5·9 to 8·3	5·4 to 7·6	5·1 to 7·2	4·8 to 6·8	4·6 to 6·4	4·4 to 6·2

The foregoing ratios are calculated by the usual formula, treating the concrete slab as a beam freely supported at both ends, and correspond to tensile stresses of 30 and 60 lb. per square inch respectively.

For example, if the total floor load is 200 lb. per foot super and the (total) thickness of the concrete is 6 inches, the maximum spacing of the joists for poor unreinforced concrete will be $5·4 \times 6 = 32·4$ inches, say 2′ 8″, or for first-class concrete $7·6 \times 6 = 45·6$ inches, say 3′ 9″.

N.B.—The British Standard Specification 449 gives a more rough-and-ready solution, putting the maximum ratio as *six* times the thickness of the concrete, unless " suitable transverse reinforcement " is provided (irrespective of the floor load).

5. WORKING STRESSES. (For War Emergency stresses, see page 6.)

Table B is designed to conform with § 12 of British Standard Specification 449, which permits of a working stress in filler joists of 9 tons per square inch.* Figures to the left of the heavy line are determined, however, by the safe compressive stress in the concrete (taken as one-fifteenth of 5 tons, viz., 750 lb. per square inch approx.) ; except that where this limitation would give a lower value than for the unreinforced joists with a working stress of $9 + t$ tons per square inch, the latter values are given instead, in italics.

B.S.S. 449 allows a working stress of $9 + t$ tons per sq. in. up to a maximum of 12 tons per sq. in. (for high tensile steel, $13 + 1\frac{1}{4}\ t$ up to a maximum of $16\frac{3}{4}$ tons per sq. in.), t being the thickness in inches of the concrete above the upper flange of the joist.

6. GENERAL PRINCIPLES.

The principles on which Table B is founded are equally applicable to other arrangements of beams in concrete, *e.g.*, railway bridges composed of Broad Flange Beams in concrete.

The tensile strength of the concrete is neglected and all the tension is considered as taken by the steel.

It is assumed that when the composite beam is deflected under the load, the alteration in length of the concrete is the same as that of the steel. As the elastic modulus of steel is about 15 times that of the concrete, the stresses in the steel must be 15 times the stresses in the concrete. Thus, if the concrete is stressed to 600† lb. per square inch, the steel in contact with it will be stressed to 4 tons per square inch.

In calculating the strength of such a beam, it can be treated as consisting entirely of steel, but with the area of the concrete divided by 15‡ and *all* the concrete below the neutral axis omitted.

* " The strength of filler floor beams entirely encased in a concrete floor slab may be estimated on the basis of the combined moment of inertia of the steel and surrounding concrete calculated as in reinforced concrete, neglecting the strength of concrete in tension, and taking the limit of flexural stress in the steel at 9 tons per square inch for mild steel, 12 tons for high tensile steel " (§ 12).

† The London County Council By-Laws, 1937, allow a compressive stress of 750 lb. per sq. inch (for 1 : 2 : 4 mixture of concrete), as adopted for Table B. For a lower stress, the values of Rc given in Table B must be reduced proportionately.

‡ The formulæ given do not differentiate between the two cases (1) when the neutral axis comes outside the joist, and (2) when it comes inside the joist, but the theoretical error in using the same formulæ for both cases is immaterial.

JOISTS IN CONCRETE.—Continued.

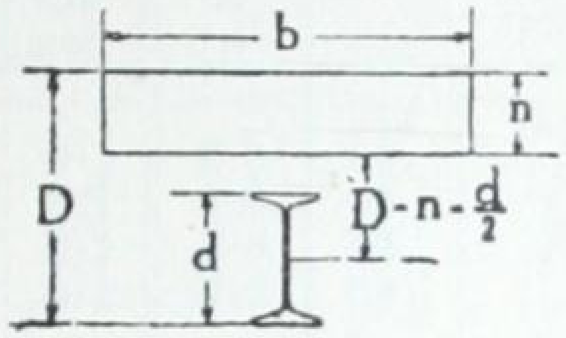


Fig. 1.

The neutral axis will pass through the centre of gravity of this equivalent section and the moment of inertia and section modulus can be calculated in the usual way.

If d = depth of the steel joist (see Fig. 1),
- A = its area,
- I = its moment of inertia,
- M = its section modulus,
- D = depth of the composite beam measured from underside of joist,
- b = breadth of the composite beam,
- n = distance of neutral axis from top of composite beam,
- Mc = compression section modulus of the composite beam,
- Mt = tension section modulus of the composite beam,

Then
$$n = \sqrt{\left\{\frac{15A}{b}\left(2D-d+\frac{15A}{b}\right)\right\}} - \frac{15A}{b}$$

$$Mc = \left\{\frac{bn^3}{3 \times 15} + A\,(D-n-\tfrac{1}{2}d)^2 + I\right\} \div n$$

$$Mt = \left\{\frac{bn^3}{3 \times 15} + A\,(D-n-\tfrac{1}{2}d)^2 + I\right\} \div (D-n)$$

If Rc = resistance moment of composite beam when concrete is fully stressed,
- c = working compressive stress (4 tons per square inch, equivalent to a stress in the concrete of 600 lb. per square inch),
- Rt = resistance moment of composite beam when steel is fully stressed in tension,
- t = working tensile stress in the steel (9 tons per square inch in the table on page 229),

Then $Rc = Mc \times c$ in ton-inches, if all the length units are expressed in inches,
and $Rt = Mt \times t$ in ton-inches, if all the length units are expressed in inches.

When $n \div (D-n) = 4 \div 9$, $n = \cdot 308D$ and $R_c = R_t$, each being expressed in the same units.

It is the value of R_c or R_t, whichever is the smaller, in ton-inches for various values of *b* that is given in Table B on page 229 for various sections and depths (D). It will be seen that the value of *b* is taken as the distance between the joists, centre to centre.

TABLE A. BENDING MOMENTS

IN CONCRETE FLOORS.

Ton-inches, per foot of width.

Total Floor Load per sq. foot.		Span between Main Girders, feet.											
		5′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′	16′
Cwts.	Lb.												
...	40	0·7	1·0	1·3	1·7	2·2	2·7	3·2	3·9	4·5	5·2	6·0	6·9
...	50	0·8	1·2	1·6	2·1	2·7	3·3	4·0	4·8	5·7	6·6	7·5	8·6
$^1/_2$	56	0·9	1·3	1·8	2·4	3·0	3·7	4·5	5·4	6·3	7·3	8·4	9·6
...	60	1·0	1·4	2·0	2·6	3·3	4·0	4·9	5·8	6·8	7·9	9·0	10·3
...	70	1·2	1·7	2·3	3·0	3·8	4·7	5·7	6·7	7·9	9·2	10·6	12·0
...	80	1·3	1·9	2·6	3·4	4·3	5·4	6·5	7·7	9·1	10·5	12·1	13·7
...	90	1·5	2·2	2·9	3·9	4·9	6·0	7·3	8·7	10·2	11·8	13·6	15·4
...	100	1·7	2·4	3·3	4·3	5·4	6·7	8·1	9·6	11·3	13·1	15·1	17·2
1	112	1·9	2·7	3·7	4·8	6·1	7·5	9·1	10·8	12·7	14·7	16·9	19·2
...	120	2·0	2·9	3·9	5·1	6·5	8·0	9·7	11·6	13·6	15·8	18·1	21
...	140	2·3	3·4	4·6	6·0	7·6	9·4	11·3	13·5	15·8	18·4	21	24
...	150	2·5	3·6	4·9	6·4	8·1	10·0	12·1	14·5	17·0	19·7	23	26
...	160	2·7	3·9	5·2	6·8	8·7	10·7	13·0	15·4	18·1	21	24	27
$1^1/_2$	168	2·8	4·0	5·5	7·2	9·1	11·2	13·6	16·2	19·0	22	25	29
...	180	3·0	4·3	5·9	7·7	9·8	12·0	14·6	17·4	20	24	27	31
...	200	3·3	4·8	6·6	8·6	10·8	13·4	16·2	19·3	23	26	30	34
2	224	3·7	5·4	7·3	9·6	12·1	15·0	18·1	22	25	29	34	38
...	250	4·2	6·0	8·2	10·7	13·6	16·7	20	24	28	33	38	43

1. MODE OF USE. Having ascertained the Bending Moment from this table, select from Table B an arrangement of joists and concrete providing an equal moment of resistance. (But see also page 6 for War Emergency stresses.)

2. FORMULA. If w = total load in cwts. per square foot and L = span of joists (feet), then the load W on each foot of width will be $1/20\ w.L$ tons. And the Bending Moment (ton-inches) will be $W \times 12L \div 8$, viz., $3/40\ w.L^2$, tabulated above.

TABLE B. MOMENTS OF RESISTANCE

OF JOISTS IN CONCRETE.

Ton-inches, per foot of width.

R.S. JOIST. Size.	Wt. per Foot.	Section Modulus.	Effective Depth of Concrete.	Spacing of Joists, centre to centre. 1′ 0″	1′ 6″	2′ 0″	2′ 6″	3′ 0″	3′ 6″	4′ 0″	4′ 6″	Maximum Span (32D).
Ins.	Lb.	Ins.³	D.									
3 × 1½	4	1·11	4″	11·5	9·6	7·6	6·2	5·3	4·6	4·1	3·7	10′ 8″
,,	,,	,,	5″	15·4	13·6	10·9	8·9	7·6	6·6	5·9	5·3	13′ 4″
3 × 3	8½	2·54	4″	*25*	*16·9*	*12·7*	11·1	10·2	9·3	8·1	7·5	10′ 8″
,,	,,	,,	5″	*28*	*18·6*	16·3	15·1	14·1	13·1	11·7	10·5	13′ 4″
4 × 1¾	5	1·83	5″	18·5	14·9	11·6	9·5	8·0	7·0	6·1	5·5	13′ 4″
,,	,,	,,	6″	23	19·7	15·3	12·9	10·7	9·3	8·2	7·4	16′ 0″
4 × 3	10	3·89	5″	*39*	*26*	*19·4*	17·2	15·4	13·4	11·9	10·7	13′ 4″
,,	,,	,,	6″	*43*	*29*	23	22	20	17·5	15·6	14·0	16′ 0″
4¾ × 1¾	6½	2·83	5¾″	*28*	22	16·9	13·8	11·7	10·2	9·0	8·1	15′ 4″
,,	,,	,,	6¾″	31	27	21	17·6	15·0	13·0	11·6	10·4	18′ 0″
5 × 3	11	5·47	6″	*55*	*36*	28	24	21	18·0	15·9	14·2	16′ 0″
,,	,,	,,	7″	*60*	*40*	32	29	25	22	19·7	17·7	18′ 6″
6 × 3	12	7·00	7″	*70*	*47*	37	31	26	22	19·9	17·8	18′ 6″
,,	,,	,,	8″	*77*	*51*	41	36	31	27	24	22	21′ 4″
7 × 4	16	11·29	8″	*113*	*75*	*56*	47	40	35	31	27	21′ 4″
,,	,,	,,	9″	*124*	*83*	*62*	53	46	40	36	32	24′ 0″
8 × 4	18	13·91	9″	*139*	*93*	*70*	58	49	43	38	34	24′ 0″
,,	,,	,,	10″	*153*	*102*	*77*	65	56	48	43	39	26′ 8″

MODE OF USE. Find from Table A the Bending Moment (per foot of width) corresponding to the given span and floor load. Then select from the table above an arrangement which will give an equal Moment of Resistance.

STRESSES, ETC. Figures to the right of the heavy line correspond to a tensile stress of 9 tons per square inch in the steel. Those to the left of it, correspond to a compressive stress in the concrete of approximately 750 lb. per square inch (one-fifteenth of 5 tons per square inch, see §6). But where the moments of resistance thus calculated are less than those of unreinforced joists stressed to $9 + t$ tons per square inch extreme fibre stress (where t is the thickness of concrete above the upper flange of the joist), the latter values are substituted, in italics. For further explanation, see § 5.

TABLE C. WEIGHTS OF CONCRETE FLOORING.

PER FOOT SUPER, APPROXIMATELY.

Thickness of Concrete.	Plain. Pounds per sq. ft.	Plain. Cwts. per sq. ft.	Plain. Tons per 100 sq. ft.	Reinforced. Pounds per sq. ft.	Reinforced. Cwts. per sq. ft.	Reinforced. Tons per 100 sq. ft.
½ inch	5·8	·05	·26	6·2	·06	·28
1 ,,	11·7	·10	·52	12·5	·11	·56
2 inches	23	·21	1·04	25	·22	1·12
3 ,,	35	·31	1·56	37	·33	1·67
4 ,,	47	·42	2·08	50	·45	2·23
5 ,,	58	·52	2·60	62	·56	2·79
6 ,,	70	·62	3·12	75	·67	3·35
7 ,,	82	·73	3·65	87	·78	3·91
8 ,,	93	·83	4·17	100	·89	4·46
9 ,,	105	·94	4·69	112	1·00	5·02
10 ,,	117	1·04	5·21	125	1·12	5·58
11 ,,	128	1·15	5·73	137	1·23	6·14
12 ,,	140	1·25	6·25	150	1·34	6·70

The assumed weights of concrete are: Plain, 140 lb.; reinforced, 150 lb., per cubic foot.

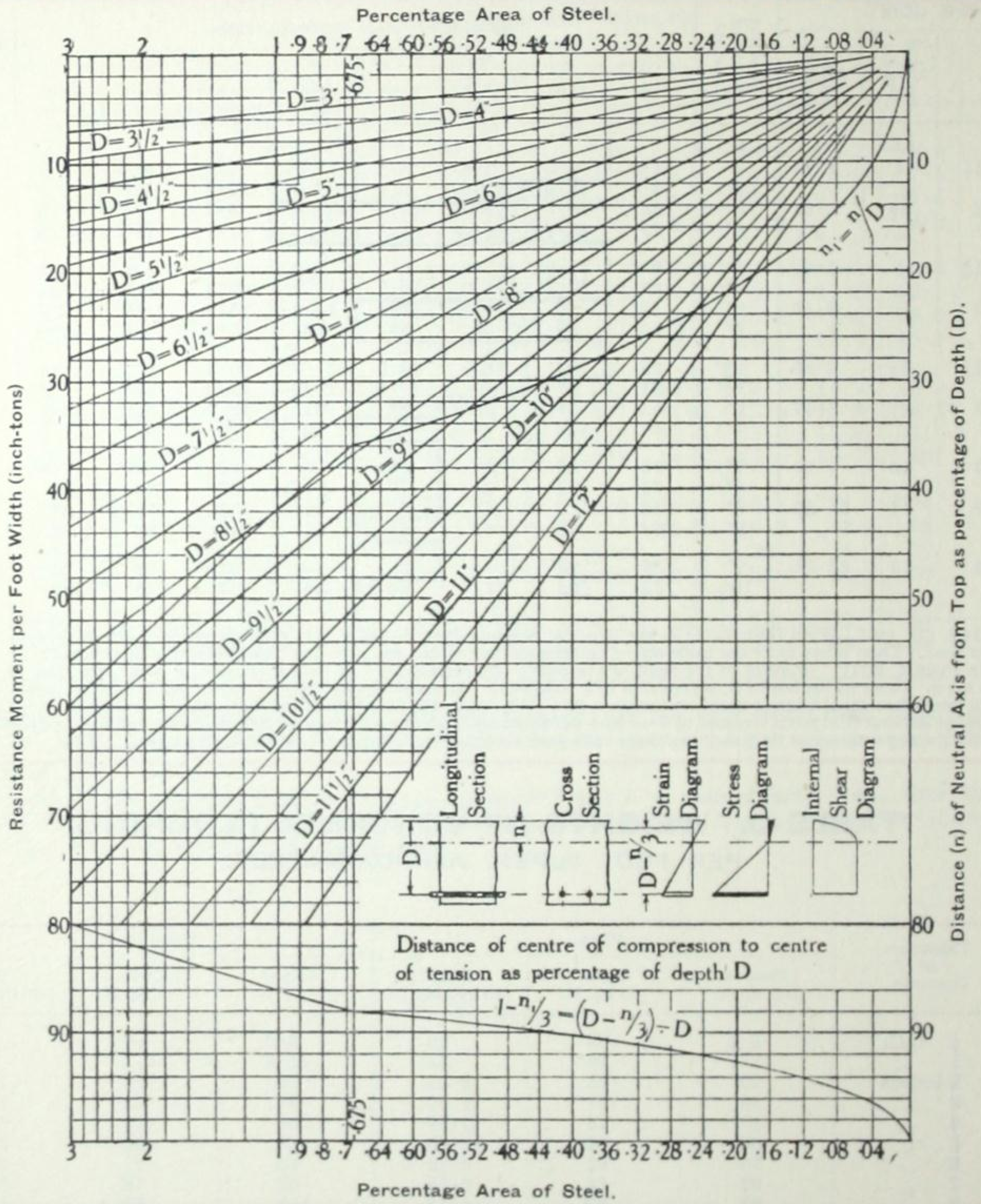
Or the weight may be taken with sufficient accuracy for practical purposes as 12 lb. per square foot, per inch of thickness—viz., 144 lb. per cubic foot.

Welding.
Plates, Inertia.
Tests, Extras.
Weights, Measures.
Math. tables.
Index, Code.

REINFORCED CONCRETE BEAMS AND SLABS.

RESISTANCE MOMENT PER FOOT WIDTH.

For Tables for Joist Reinforcement, see pages 228 and 229.



SCOPE OF CHART. The chart is applicable to rectangular slabs and beams and also to Tee beams of reinforced concrete where the neutral axis lies within the slab portion; it assumes tensile reinforcement only and is based on the common assumptions in reinforced concrete calculation embodied in the L.C.C. regulations for reinforced concrete, viz., tension in concrete neglected, straight line law for deformation, a constant ratio (15) of Moduli of Elasticity of steel and concrete.

STRESSES. The lines are drawn for a maximum stress of either 600 lb. per square inch in the concrete or 16000 lb. per square inch in the steel. But the stresses now allowed by the London County Council By-Laws, 1937, are 750 and 18000 lb. per sq. inch, respectively.

POSITION OF NEUTRAL AXIS. This can be read from the diagram by means of the curve in the top portion.

METAL ARC WELDING

PRINTED ELSEWHERE

Welding.

Plates, Inertia.

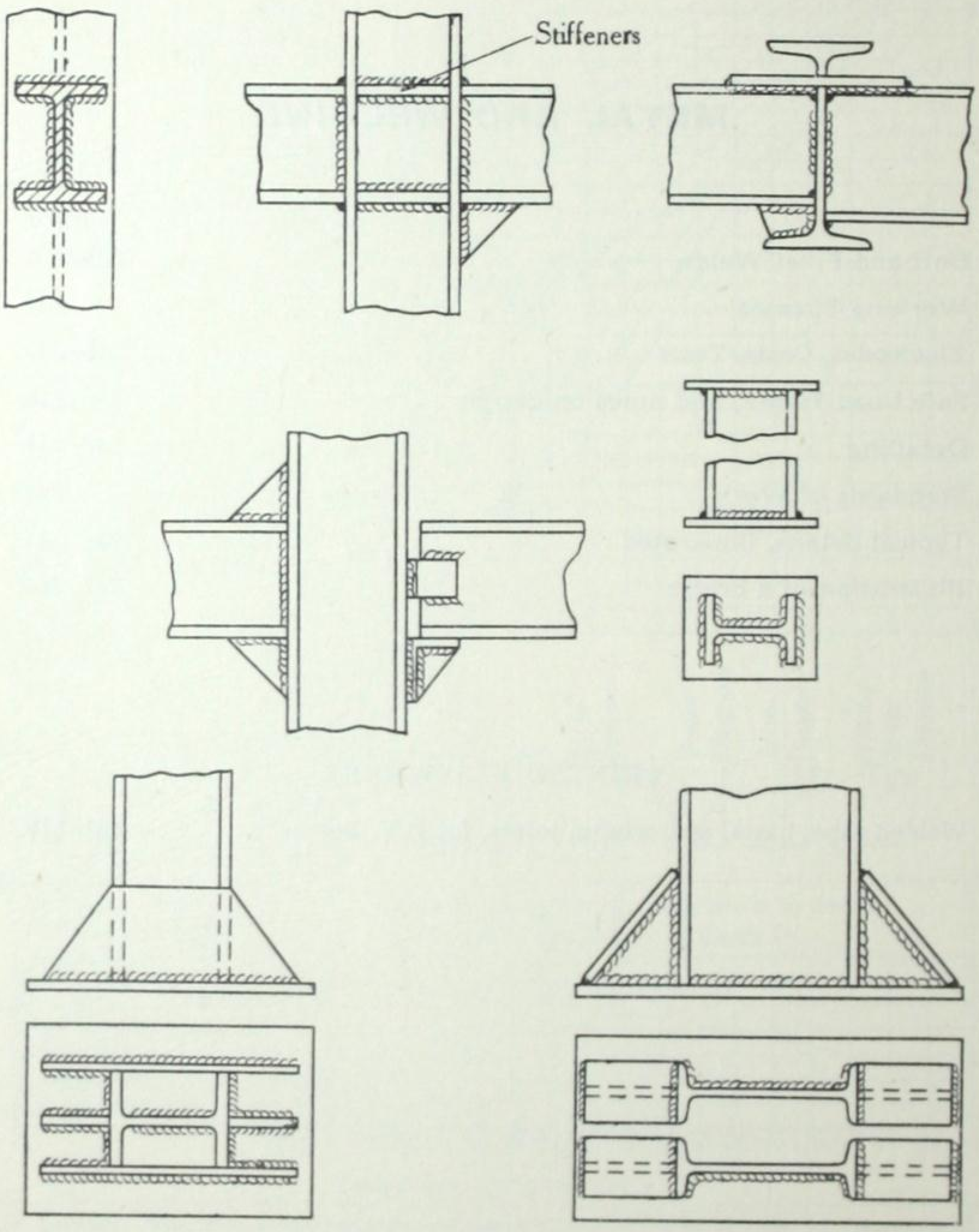
Tests, Extras.

Weights, Measures.

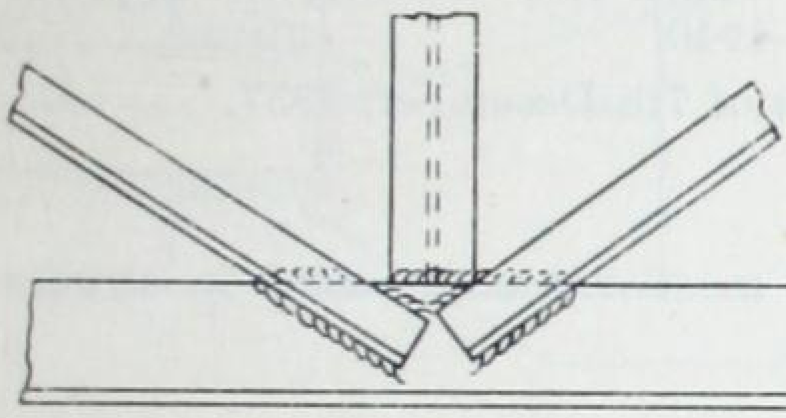
Math. tables.

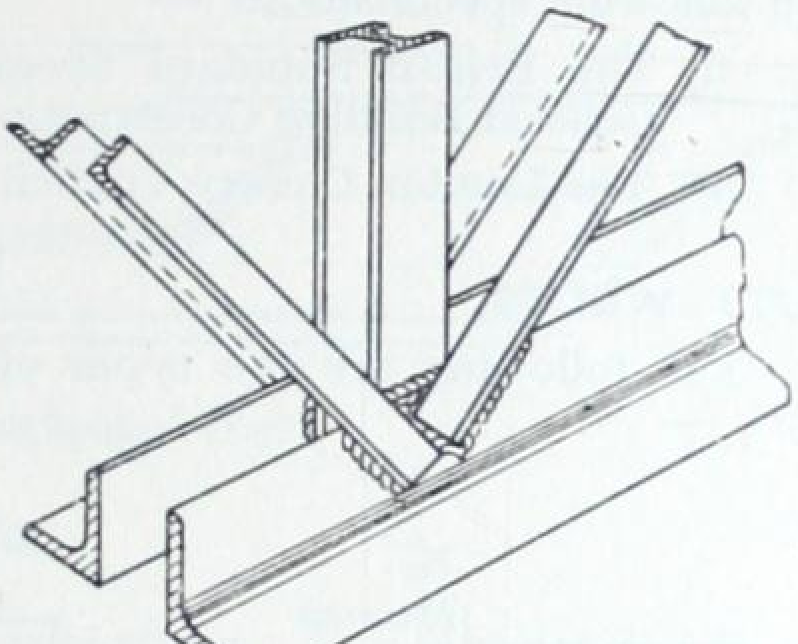
Index, Code.

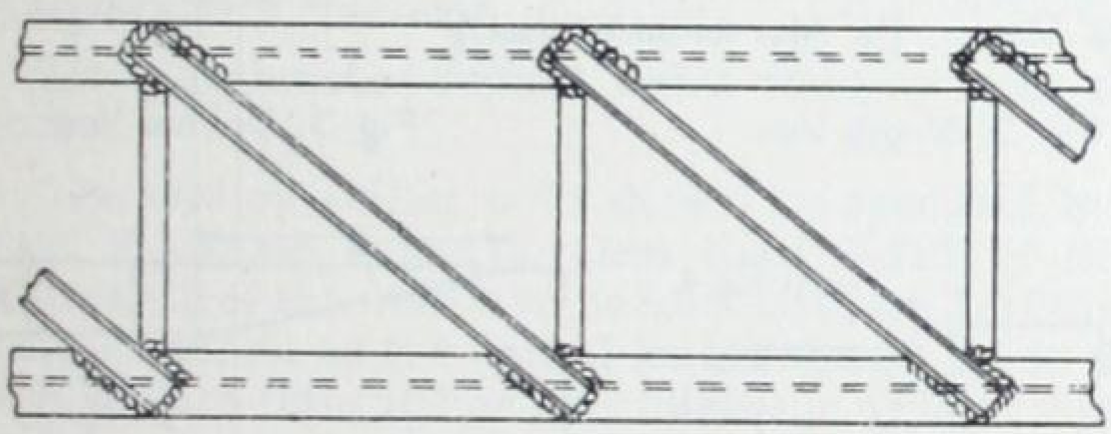
TYPICAL WELDING DETAILS.

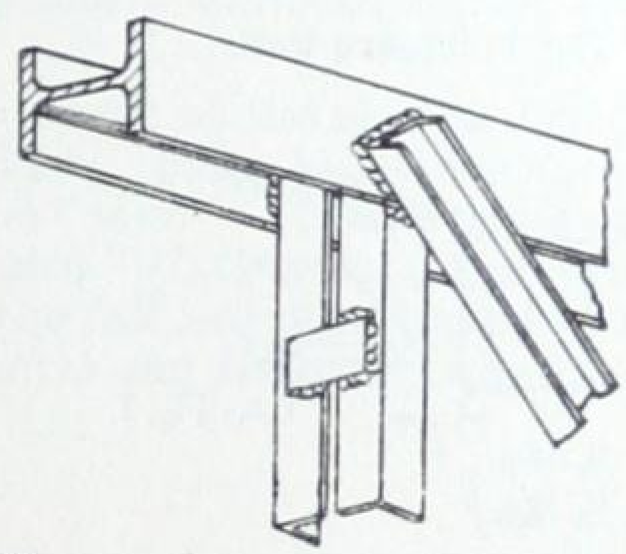


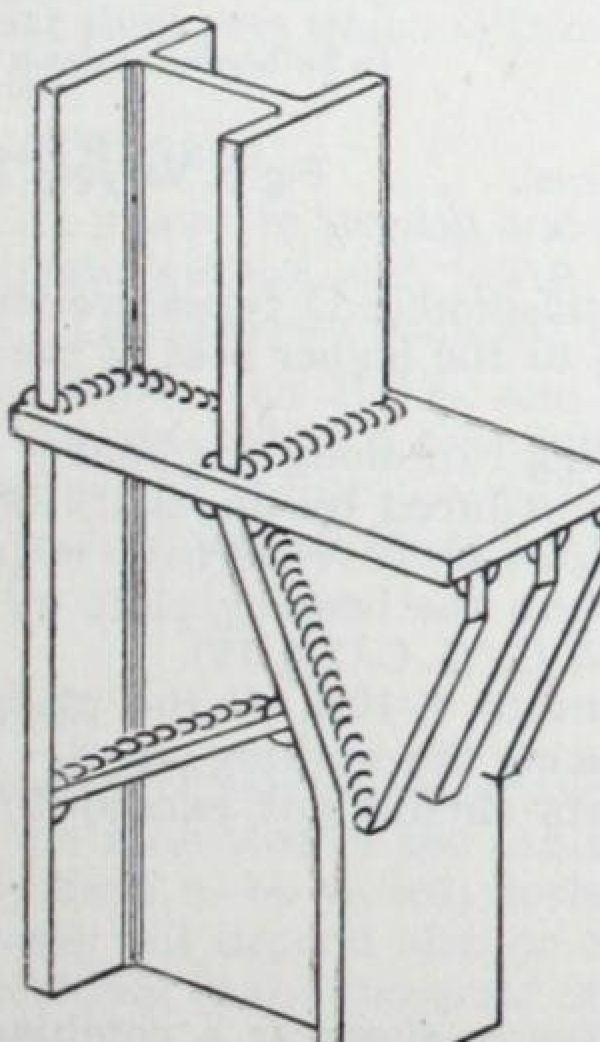
TYPICAL WELDING DETAILS.—Continued.

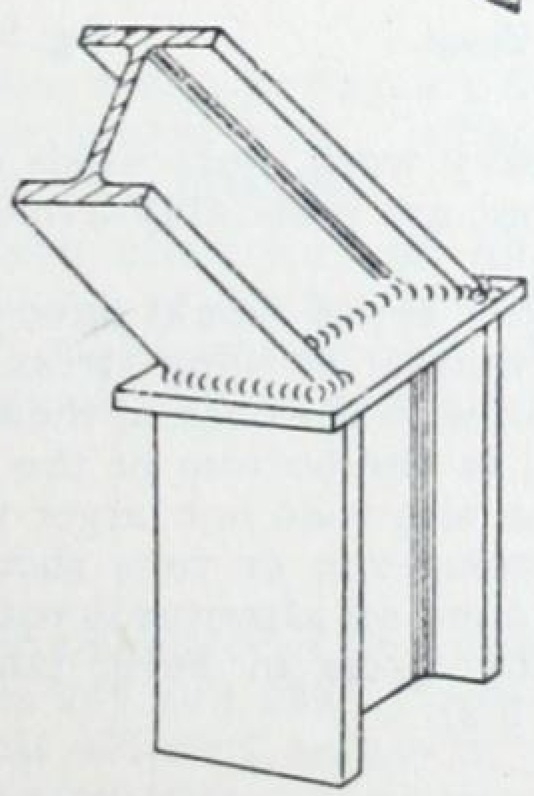












For examples of bridge construction, see pages 247–8.

METAL ARC WELDING.

In the following notes, the abbreviations B.S.S. and L.C.C. refer respectively to the following specifications :—

(i) The British Standard Specification for Metal Arc Welding as applied to General Building Construction, No. 538—1940.

(ii) The London County Council Regulations of 7th December, 1937.

BUTT WELDS.

The following are the types of butt weld most commonly used in structural work :—

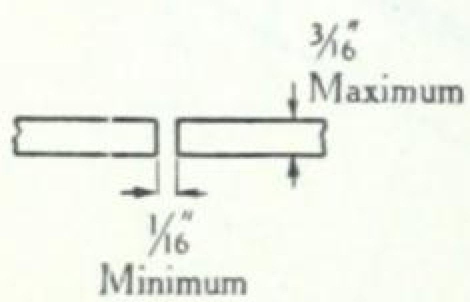


Fig. 1. Square Butt.

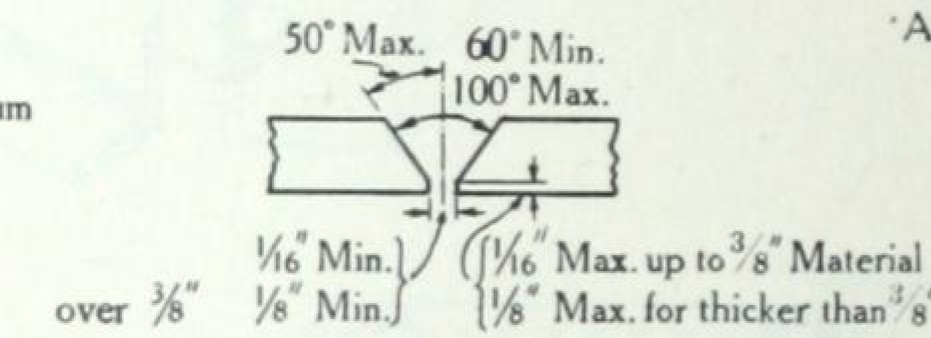


Fig. 2. Single Vee.

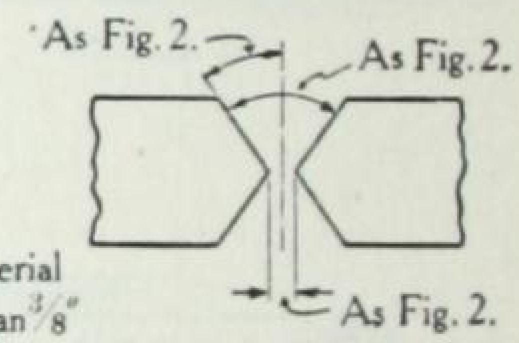


Fig. 3. Double Vee.

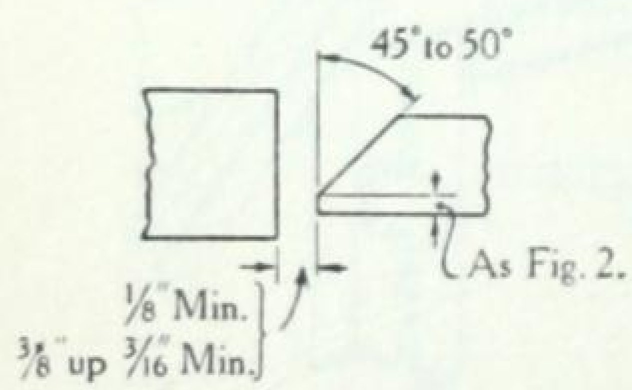


Fig. 4. Single Bevel

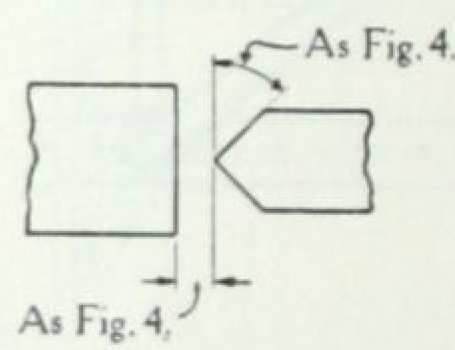
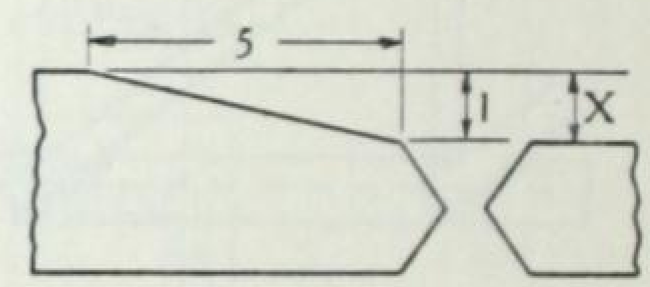


Fig. 5. Double Bevel.



To be bevelled as above where x exceeds 1/4"

Fig. 6. Varying Thicknesses.

In very heavy work, butt welds of J, U and double U types are also employed on occasion ; but are preferably avoided owing to the higher cost of the preparatory machining.

The " single " types should have a reinforcing run along the back ; when this is impossible the normal working stress should be reduced by one-half, unless another part is in contact with the back of the vee, the plates are bevelled to an edge, and fusion is ensured both in the bottom of the vee and with the backing plate by making the first run with an electrode not larger than 8 S.W.G. (L.C.C. § 17).

The reinforcing run or runs should amount to 1/10th of the plate thickness ; they may be ground off afterwards without reducing the working stress.

The working stress in bevel (and J) joints should not exceed 3/4ths of the normal (L.C.C. § 8).

FILLET WELDS

These transmit longitudinal shear or transverse shear or a combination of the two, and may be " end welds " or " side welds." Both are illustrated in Fig. 7 overleaf.

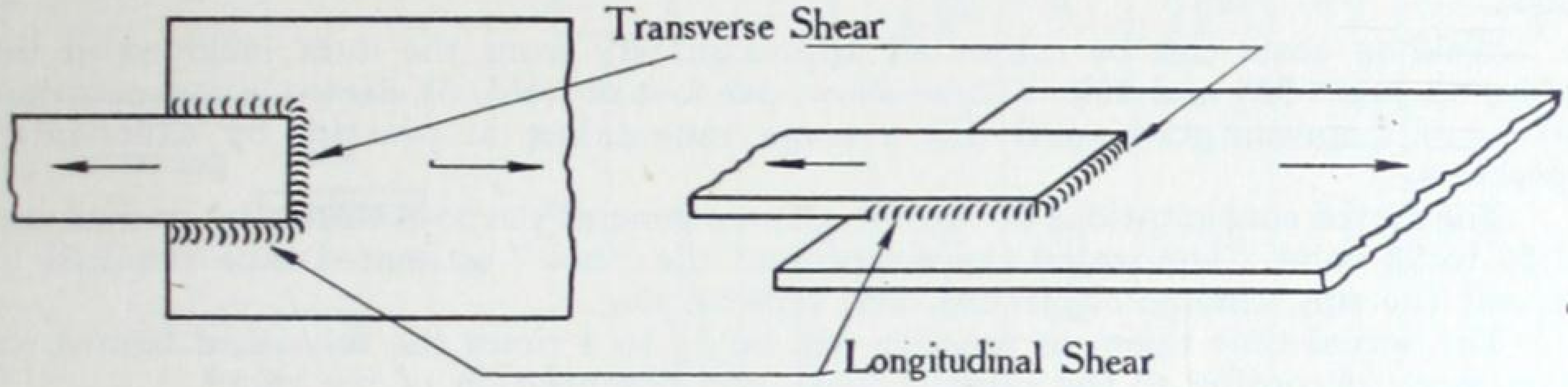


Fig. 7.

In *end* welds, the line of weld is across the lines of stress. In *side* welds, the line of weld is along the lines of stress, and the weld tends to fail in shear along the plane of the throat. It is usual now to make fillet welds with the legs equal, and with the surface slightly convex.

Most authorities regard welds transverse to the direction of stress as the more efficient.

The *size* of a fillet weld should be specified by the length of the shorter leg, the throat thickness being not less than 0·707 of this (B.S.S., page 8). Accordingly, the strength of the weld is to be calculated on 7/10ths of the " size." Its effective length should be taken as the actual length minus twice the " size " (L.C.C. 21) ; but where end fillets are returned as side fillets for at least 1 inch, the full length of the end fillet can be deemed effective (L.C.C. 41). In certain Continental and Indian specifications it is the throat thickness which is taken as the " size."

WORKING STRESSES

The L.C.C. allows, in tension and compression, 8 tons per square inch. In shear : in webs of plate girders and joists, 6 tons per square inch ; otherwise 5 tons per square inch. The table on page 237 is based on these stresses.

In *Fillet welds*, the B.S.S. and L.C.C. both allow for *end* fillets 6 tons per square inch, for *side* fillets 5 tons per square inch ; calculated in either case on the sectional area at the throat (i.e. 0·7 of " size " multiplied by the effective length). The allowable stress for *end* fillets is 7 tons per square inch, as in the table of safe loads on page 239.

ELECTRODES

Suitable sizes of electrodes, according to the thickness of the plate and the space to be filled, are indicated in the tables on pages 237 and 239. These and the stated currents may have to be varied, however, to suit different makes of electrode. The choice of gauge will depend also on the welding position. A variety of grades are employed according to the character of the work, composition of the parent metal, etc.

COST.

Welding costs can be estimated approximately from the data included in the tables on pages 237 and 239. These show, per foot of weld, (i) electrode consumption, (ii) current consumption, and (iii) average time taken in practice by experienced operators.

The stated consumptions of current assume general purpose electrodes and an arc of 20 to 23 volts. The stated times represent the " net " estimated time required to deposit the run, change electrodes, and remove slag.

The actual time taken in practice will be $1\frac{1}{2}$ to 4 times the tabulated figures, or even more, according to the class of work and organisation of the shop.

TESTS.

The various methods employed for ensuring the quality of welded work are as follows :—

(i) Inspection of welds after each run. On important work X-ray or Gamma ray examination is also used.

(ii) Periodic testing of operators, usually at regular intervals by the works management. The usual tests are bend tests on butt welds and inspection tests on fillet welds. For the latter a single fillet weld between two plates at right angles is broken for examination.

(iii) Electrodes are tested by bending, tensile, and Izod tests on all weld-metal test pieces. Tensile tests on butt and fillet welds are made for a specified quantity of electrodes supplied ; see for example B.S.S. 639, 1935 (§ 8).

On all weld-metal tests, covered alloy electrodes of the best makes (for structural work) usually give such results as :—

Tensile 28/33 tons, Yield Point 21/25 tons, Elongation 15/25% on 8 diameters, Izod 40/60 ft. lb. The minima required by B.S.S. 538/1934 were :— 28 tons per square inch tensile, 20% elongation on 3·54 diameters, 30 ft. lb. Izod.

DESIGN.

(i) Joints should be so designed that the stresses in the welds are readily determined—butt welds in direct tension or compression and fillet welds in end shear and side shear. When stresses cannot be so resolved, special tests on the type of joint should be made. Welds should be so arranged that there are no bending or twisting moments about their longitudinal axes, XX in Fig. 8.

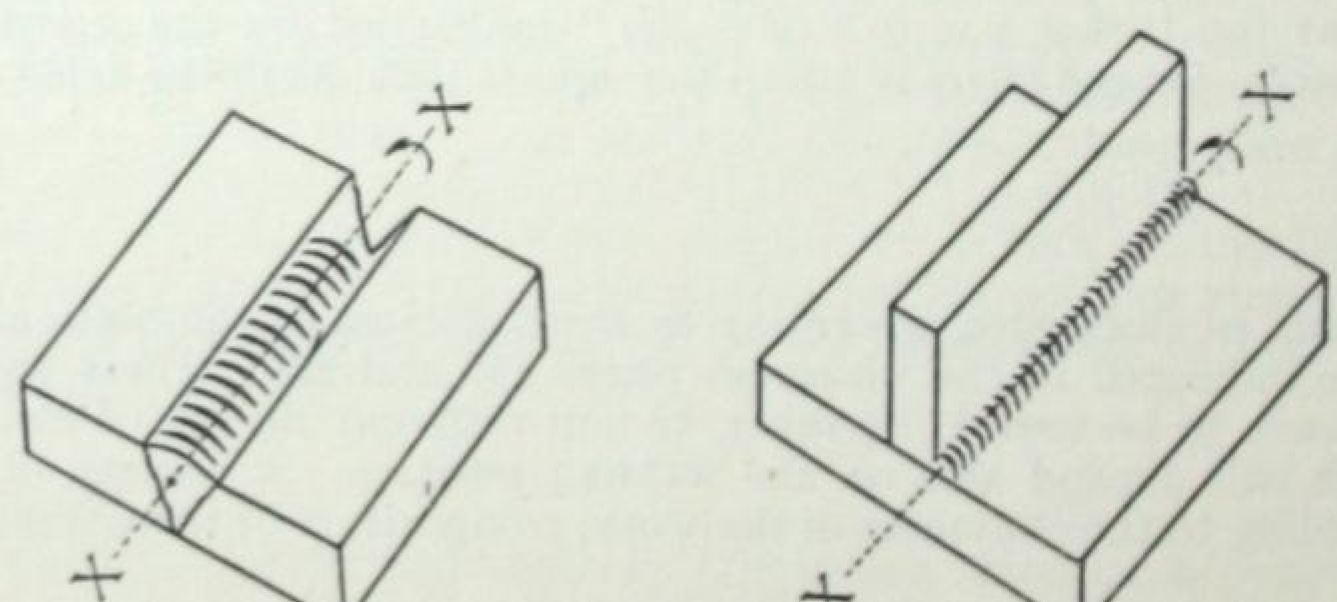
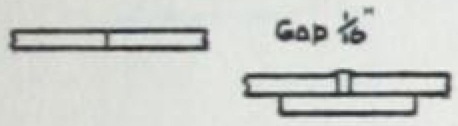
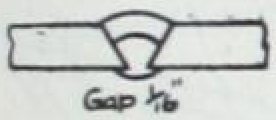
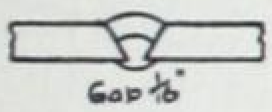
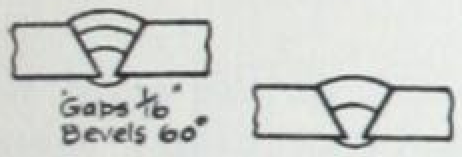
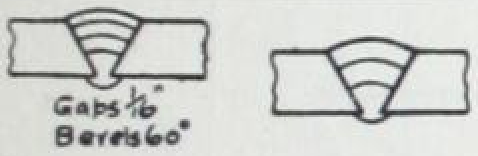
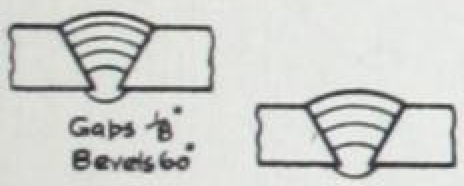
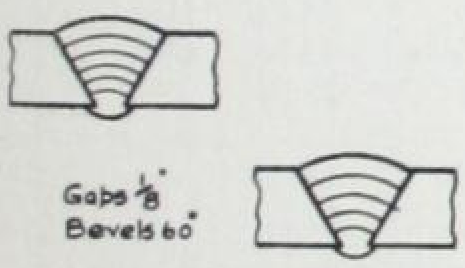
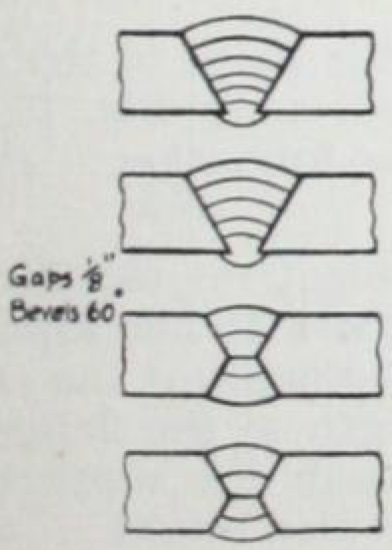


Fig. 8.

Table 1. BUTT WELDS.

Thickness of Plate	Method.	Runs.	Electrode.	Inches of Weld per Electrode.	Electrode per ft. of Weld.	Current.	Consumption per ft. of Weld.	Time per foot.	Safe load per linear inch. Tension.	Shear.
Ins.		No.	S.W.G.	Ins.	Ft.	Amps.	K.W.H.	Mins.	Tons.	Tons.
1/8		2 1	8 8	21 14½	1·72 1·24	170 170	·16 ·11	2 1	1·00	0·62
3/16		1 1	10 10	15 11	2·84	100 120	·23	6	1·50	0·94
		1 1	10 8	15 16½	1·20 1·09	100 170	·21	5		
1/4		1 1	10 8	15 9	1·20 2·00	100 170	·30	6	2·00	1·25
		1 1	10 6	15 12	1·20 1·50	100 210	·31	5		
5/16		1 2	10 8	12 12	1·50 3·00	100 170	·45	9	2·50	1·56
		1 1	10 6	12 8	1·50 2·25	100 210	·47	8		
3/8		1 3	10 8	12 12	1·50 4·50	100 170	·63	13	3·00	1·87
		1 2	10 6	12 12	1·50 3·00	100 210	·56	10		
1/2		3 2	8 8	12 7	4·50 5·14	150 170	·99	17	4·00	2·50
		1 1 2	8 6 6	12 12 } 9 }	1·50 5·50	150 210	·99	15		
5/8		1 3 1 1	8 8 8 8	12 9 } 6 } 5 }	14·10	150 170	1·54	27	5·00	3·12
		1 1 1 1 1	8 6 6 6 6	12 12 } 10 } 6 } 5½ }	1·50 9·60	150 210	1·62	23		
3/4		1 1 1 1 2	8 6 6 6 6	12 12 } 10 } 9 } 6 }	1·50 11·30	150 210	1·85	27	6·00	3·75
		1 2 2	8 4 4	12 12 } 6 }	1·50 9·00	150 250	2·01	25		
		2 2	6 5/16"	16½ 12	2·18 3·00	200 560	1·48	13		
		1 2 1 2	6 4 4 4	16½ 12 } 16½ } 9 }	1·09 8·09	240 340 340 340	1·78	19		

1. The tabulated safe loads for butt welds in tension (or compression) and shear correspond to working stresses of 8 and 5 tons per square inch respectively (see page 235).

2. If a single vee butt weld is not finished with a bead along the back, reduce the stress by 50% (except in the conditions mentioned on page 234).

3. For explanation of the data on Current consumption and Time per foot, see under "Cost" on page 236 opposite.

METAL ARC WELDING.—Continued.

(ii) When stress is transmitted through a weld to parts of a member of varying rigidity, stiffening pieces should be used to transmit the stress from the flexible to the rigid parts of the member. Compare Figs. 9 and 10.

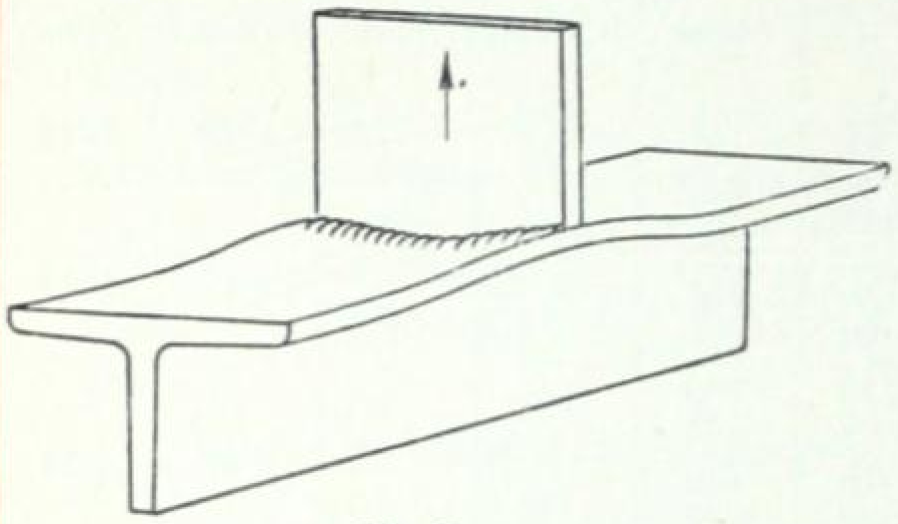


Fig. 9.

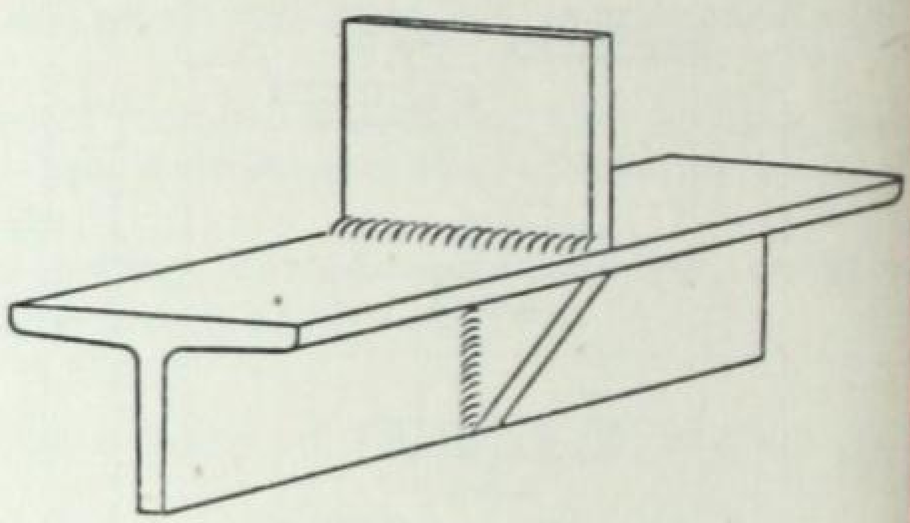


Fig. 10.

(iii) In butt welds concentration of stress is liable to occur at the ends, owing to the difficulty of finishing the ends symmetrically. It may be necessary therefore to form pads of weld metal across the ends of the beads.

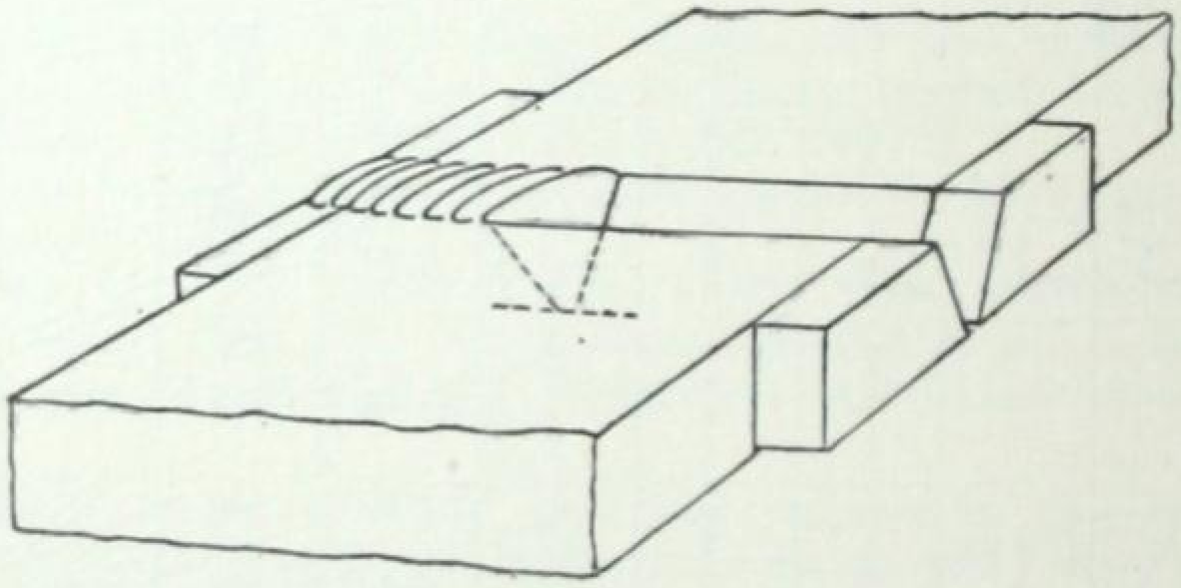


Fig. 11.

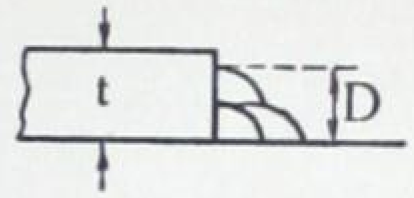
In any case, a piece of plate, or continuation pieces to give the shape of the vee, should be held or clamped to the edges of the parts being butted, as in Fig. 11, to enable the arc to be continued right up to the edge without crater formation : these plates can readily be knocked off after the operation.

(iv) Floor beams may be made continuous by making connections capable of resisting the full negative moment at the supports. Where there is longitudinal restraint of the members connected, cover straps or other reinforcement of the joint should be added, sufficient to develop at least 25% of the strength of the flange in tension. Or a beam may be made continuous by cutting through the supporting member and making any necessary splice joints at the points of contraflexure.

Where continuity is not required, the beam should be freely supported by angle cleats or other means which will allow free deflection of the beam ; and welds should be so placed as to reduce to a minimum secondary bending stresses in beam and welds.

(v) Column joints should be machined square and have sufficient welding to

Table 2. FILLET WELDS.



Size (D).	Throat Thickness.	Runs.	Electrode.	Inches of Weld per Electrode.	Electrode per ft. of Weld.	Current.	Consumption per ft. of Weld.	Time per foot.	Safe load per linear inch of Weld: End Welds.	Safe load per linear inch of Weld: Side Weld.
Ins.	Ins.	No.	S.W.G.	Ins.	Ft.	Amps.	K.W.H.	Mins.	Tons.	Tons.
1/8	·088	1	10	15	1·20	120	0·09	1	0·62	0·44
		1	8	23	·78	170	0·11	1		
3/16	·133	1	10	11	1·60	120	0·13	2	0·93	0·66
		1	8	13	1·40	150	0·16	2		
1/4	·176	1	8	10	1·80	170	0·17	2	1·24	0·88
		1	6	12	1·50	225	0·24	2		
		1	4	14	1·30	290	0·27	2		
5/16	·221	3	10	9	6·00	120	0·36	6	1·55	1·10
		1	8	18						
		1	8	17	3·60	165	0·44	5		
		1	8	12						
		1	6	8½	2·10	220	0·35	3		
		1	4	11	1·60	300	0·31	2		
3/8	·265	3	8	12	4·50	170	0·54	6	1·85	1·33
		3	6	16	3·40	200	0·42	4		
1/2	·354	6	8	16	6·80	170	0·90	10	2·48	1·77
		4	6	14	5·20	230	0·85	7		
		3	4	18	3·00	300	0·79	5		
5/8	·441	8	8	11	13·12	170	1·53	16	3·09	2·21
		6	6	12	9·00	210	1·42	13		
		5	4	13	6·90	250	1·46	11		
3/4	·530	9	6	12	13·50	210	2·10	19	3·71	2·65
		7	4	13	9·70	250	2·10	16		

1. The tabulated safe loads are based on working stresses of 7 and 5 tons per square inch, for End and Side Fillets respectively (see page 235). Throat thickness taken as ·707 of the size.

2. For explanation of the data on Current consumption and Time per foot, see under "Cost" on page 236.

transmit all forces other than wholly compressive forces. If there are no other forces, sufficient welding for erection and location purposes (compare B.S.S. page 23 §o, L.C.C. § 48).

(vi) In lap joints between plates, the lap should be at least four times the thickness of the thinner plate (B.S.S. page 23 § j, L.C.C. § 42).

(vii) The effective length of a fillet weld to transmit loading should not be less than 2″ nor less than six times the size of the weld (L.C.C. § 22).

(viii) Contact surfaces exceeding ½″ in width exposed to the weather should be sealed against ingress of water (Cf., L.C.C. § 36).

(ix) Welds used for connecting bracing members should be designed to develop the full strength of the member (B.S.S. page 22 § e, L.C.C. § 35).

(x) Slots should not be filled with weld metal, and their width should be at least twice the thickness of the plate, with a minimum of 1″. Corners should be rounded to a radius not less than the thickness of the plate, with a minimum of ½″. The distance from the edge of the slot to the edge of the slotted plate should be not less than twice the thickness of the plate (L.C.C. § 38).

(xi) In order to minimise costs of handling in the fabricating shop, holes for erection purposes should, whenever possible, be in the connections (cleats, gussets, etc.), not in the main members.

STRESS CALCULATION

The direct stress in fillet and butt welds stressed in tension, compression, or shear, may be computed by the formula $f = P/A$ where P is the load transmitted by the connection, and A is the effective sectional area of the weld. The bending stress, by the formula $f_1 = BM/Z$ where BM is the Bending Moment transmitted by the connection and Z the section modulus of the weld. Cases of combined bending and direct stress should be calculated separately by these two formulæ and combined (L.C.C. §§ 30–32); see pages 242–246.

SYMBOLS

Drawings and specifications should clearly indicate sizes and types of welds required ; only widely recognised symbols should be employed.

DETAILING

The length of each side fillet used in end connections should not be less than the distance between them. Side fillets may be at the edges of the members, or in slots or holes (L.C.C. § 40, cf. B.S.S. 18).

In end connections, a single end fillet should not be used without side fillets. With two or more end fillets, the ends should be turned at least 1″ to form side fillets ; in calculating the strength of the connection, if the short return welds are disregarded the full length of the end welds may be considered effective (L.C.C. § 41).

Owing to the nature of the welded joint, redistribution of stress takes place less readily than in riveted joints ; so that welded connections, unless skilfully designed, may lead to dangerous concentrations of stress. Abrupt changes of contour must be particularly avoided.

In welded work measurements should be taken from the edge of the section, rather than from gauge lines as with riveted work.

STANDARDS OF WORK

(i) The surfaces to be welded, and the adjoining metal for a distance of at least ½", must be cleaned free of rust, scale, paint, grease, mineral oil, and dirt, by wire brush, sand blast, or other effective method [L.C.C., page 5 (iv) ; B.S.S., 6a].

(ii) Means must be adopted to minimise distortion of the finished parts, e.g. by jigs, tack welding, intermittent chain, alternative side, or other effective means [cf. B.S.S. 6c, L.C.C. page 5 (vi)].

(iii) Each bead of weld metal must have the slag removed by light hammering and wire brushing before the next bead is deposited. Light chipping or peening is permissible ; hammering is not (B.S.S. 6d, L.C.C. page 5 (vii)).

(iv) The weld must show a good clean contour ; and on a cut specimen, good fusion with the parent metal. If the weld metal tends to fold over on the parent metal without proper penetration, or shows porosity or slag inclusions, it must be cut out and rewelded.

(v) Undercutting must be avoided ; if it occurs, any reduction of area from this cause must be made good by an additional run [B.S.S. 6d, L.C.C. page 5 (vii)].

(vi) Vertical or overhead welding is to be avoided when possible.

(vii) The current used must be within the range defined by the electrode manufacturer [B.S.S. 6f, L.C.C. page 5 (vii)].

(viii) Before applying paint to welded joints, they should be carefully chipped or wire-brushed ; it may also be advisable to neutralise the slag remains, if alkaline or acid (as they may be, according to the grade of electrode employed).

Table 3. TILTED FILLETS.

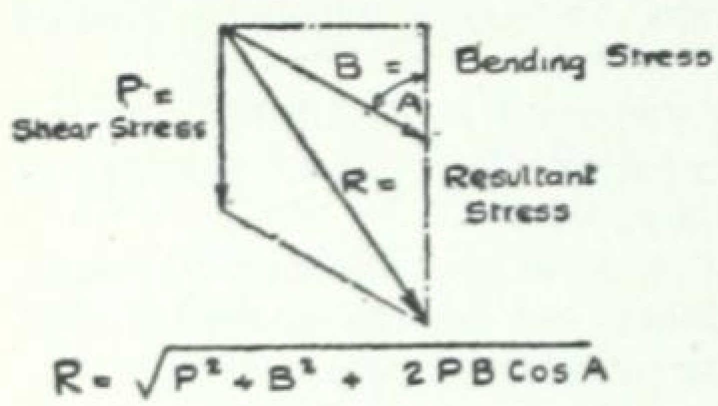
Size (D).	Throat Thickness.	Runs.	Electrode.	Inches of Weld per Electrode.	Electrode per ft. of Weld.	Current.	Consumption per ft. of Weld.	Time per ft. of Weld.	Safe load per linear inch of Weld. End Welds.	Side Welds.
Ins.	Ins.	No.	Ins.	Ins.	Ft.	Amps.	K.W.H.	Mins.		
1/4	·176	1	1/4	20	0·90	320	0·24	1·8	1·24	0·88
5/16	·221	1	5/16	21	0·86	450	0·35	1·7	1·55	1·10
3/8	·265	1	5/16	14	1·28	450	0·51	2·3	1·85	1·33
		1	3/8	18	1·00	580	0·81	2·1		
1/2	·354	1	5/16	9	2·00	480	0·87	3·3	2·48	1·77
		1	3/8	14	1·28	580	1·03	2·5		
5/8	·441	2	5/16	10	3·60	480	1·60	6·1	3·09	2·21
		2	3/8	14	2·56	580	2·07	4·8		
3/4	·530	3	5/16	9	6·00	480	2·66	9·7	3·71	2·65
		3	3/8	13	4·14	580	3·38	7·7		

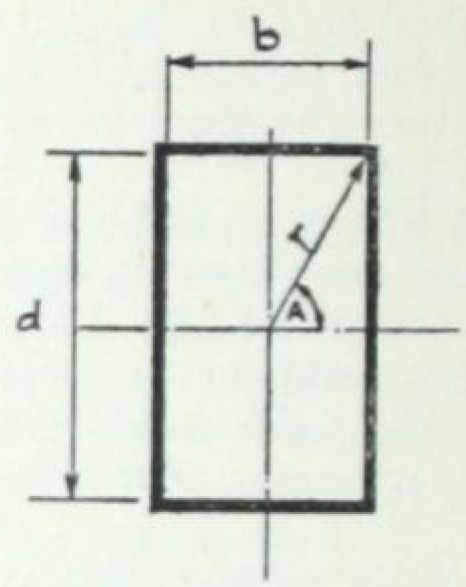
1. The tabulated safe loads correspond to working stresses of 7 and 5 tons per square inch for End and Side welds respectively (see page 235).

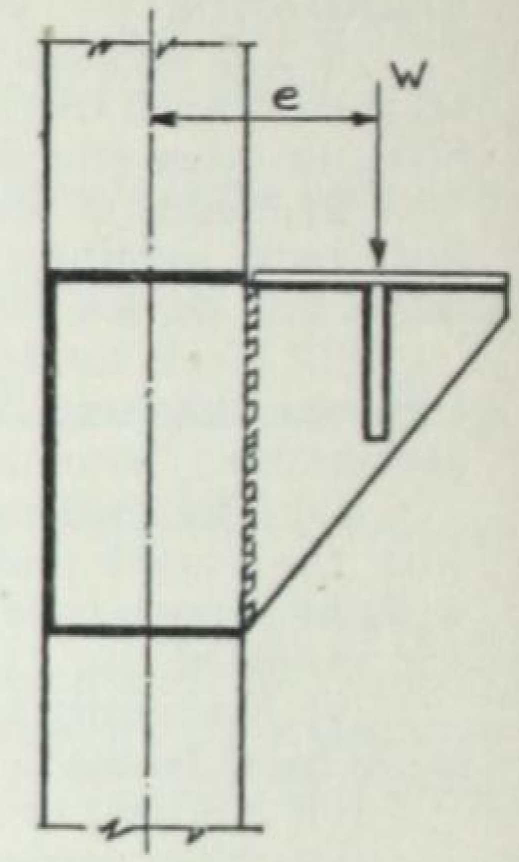
2. For explanation of the data on Current consumption and Time per foot, see under " Cost " on page 236.

WELD GROUP WITH ECCENTRIC LOAD

IN SAME PLANE







Assuming a throat thickness of 1 inch :—

Shear stress P $= \dfrac{W}{2(b + d)}$

Maximum Bending stress B $= \dfrac{Wer}{Ip}$

Ip represents the Polar Moment of Inertia of the weld group about its centre of gravity ; tabulated opposite for 1″ throat thickness.

In the vector diagram, R is the resultant maximum stress arising from the bending and direct stresses. The size of the fillet welds must be such that R will not exceed the allowable shear stress (5 tons per square inch).

Example.—If W = 10 tons, e = 7″, B = 6″, D = 10″ :—

$P = \dfrac{10}{32} = \cdot312$ tons per linear inch.

Ip (from table on page 243) = 683 ins.[4]

$r = \sqrt{3^2 + 5^2} = 5{\cdot}83$ inches.

$B = \dfrac{10 \times 7 \times 5{\cdot}83}{683} = \cdot60$ tons per linear inch.

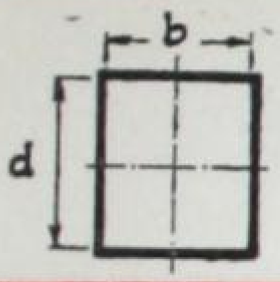
$\text{Cos } A = \dfrac{3}{5{\cdot}83} = \cdot514$

$R = \sqrt{\cdot312^2 + \cdot60^2 + (2 \times \cdot312 \times \cdot60 \times \cdot514)}$

$= \cdot81$ *tons per linear inch.*

From the table on page 239, ½″ fillet welds are required.*

* Since the combined stress is to be limited to the allowable shear stress of 5 tons per square inch, we take the safe load tabulated for Side Welds, *viz.*, 0·88 tons per linear inch.



POLAR MOMENTS OF INERTIA ABOUT CENTRE OF GRAVITY.

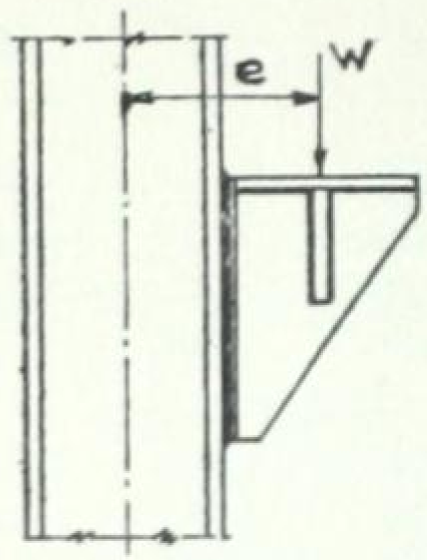
1″ throat thickness ; see opposite

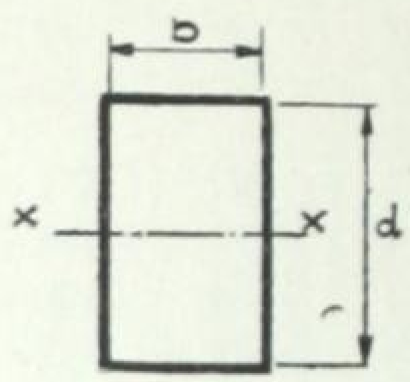
Inside Depth (d) inches.	Inside Width (b) in inches										
	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″
3	21	36	57	85	121	167	222	288	366	457	562
4	36	57	85	121	167	222	288	366	457	562	683
5	57	85	121	167	222	288	366	457	562	683	819
6	85	121	167	222	288	366	457	562	683	819	972
7	121	167	222	288	366	457	562	683	819	972	1143
8	167	222	288	366	457	562	683	819	972	1143	1333
9	222	288	366	457	562	683	819	972	1143	1333	1543
10	288	366	457	562	683	819	972	1143	1333	1543	1775
11	366	457	562	683	819	972	1143	1333	1543	1775	2028
12	457	562	683	819	972	1143	1333	1543	1775	2028	2304
13	562	683	819	972	1143	1333	1543	1775	2028	2304	2604
14	683	819	972	1143	1333	1543	1775	2028	2304	2604	2929
15	819	972	1143	1333	1543	1775	2028	2304	2604	2929	3280
16	972	1143	1333	1543	1775	2028	2304	2604	2929	3280	3659
17	1143	1333	1543	1775	2028	2304	2604	2929	3280	3659	4065
18	1333	1543	1775	2028	2304	2604	2929	3280	3659	4065	4500
19	1543	1775	2028	2304	2604	2929	3280	3659	4065	4500	4965
20	1775	2028	2304	2604	2929	3280	3659	4065	4500	4965	5461
21	2028	2304	2604	2929	3280	3659	4065	4500	4965	5461	5989
22	2304	2604	2929	3280	3659	4065	4500	4965	5461	5989	6551
23	2604	2929	3280	3659	4065	4500	4965	5461	5989	6551	7146
24	2929	3280	3659	4065	4500	4965	5461	5989	6551	7146	7776
25	3280	3659	4065	4500	4965	5461	5989	6551	7146	7776	8442
26	3659	4065	4500	4965	5461	5989	6551	7146	7776	8442	9145
27	4065	4500	4965	5461	5989	6551	7146	7776	8442	9145	9886
28	4500	4965	5461	5989	6551	7146	7776	8442	9145	9886	10667
29	4965	5461	5989	6551	7146	7776	8442	9145	9886	10667	11487
30	5461	5989	6551	7146	7776	8442	9145	9886	10667	11487	12348
31	5989	6551	7146	7776	8442	9145	9886	10667	11487	12348	13251
32	6551	7146	7776	8442	9145	9886	10667	11487	12348	13251	14197
33	7146	7776	8442	9145	9886	10667	11487	12348	13251	14197	15187
34	7776	8442	9145	9886	10667	11487	12348	13251	14197	15187	16223

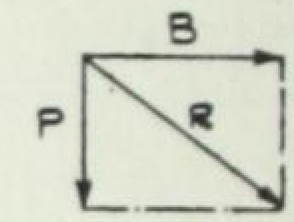
Plates, Inertia.
Tests, Extras.
Weights, Measures.
Math. tables.
Index, Code.

WELD GROUP WITH ECCENTRIC LOAD

PARALLEL TO ITS PLANE







$R = \sqrt{P^2 + B^2}$

In this typical example, the weld group securing the bracket to the column has eccentric loading W acting with a leverage perpendicular to the plane of the weld group. It must be designed to take the resultant R of the combined shear and bending stresses, and R should not exceed the allowable shear stress, say 5 tons per sq. inch. If the throat thickness is t, then :—

$$\text{The Shear stress } P = \frac{W}{2t(b+d)}.$$

$$\text{The Moment of Inertia Ixx of the side welds} = \frac{2td^3}{12} = \frac{td^3}{6}$$

$$\text{the Ixx of the top and bottom welds} = 2tb\left(\frac{d}{2}\right)^2 = \frac{tbd^2}{2}$$

$$\text{the total Ixx of the group} = t\left(\frac{d^3 + 3bd^2}{6}\right)$$

$$\text{the Modulus Zxx of the group} = \frac{2Ixx}{d} = t\left(\frac{d^2 + 3bd}{3}\right)$$

$$\therefore \text{ the Bending stress } B = \frac{We}{Zxx} = \frac{3We}{t(d^2 + 3bd)}.$$

$$\text{The combined stress } R = \sqrt{P^2 + B^2}.$$

For the purposes of calculation, the procedure is to take t in the first instance as 1″ throughout. The value of R thus ascertained for a throat thickness of 1″ is obviously also the combined stress or load per *linear* inch, whence the required size of weld can be ascertained from the safe load table on page 239.

Example.—If in the above illustration W is 13 tons, e is 12″, b is 8″, d is 12″, then, for a throat thickness of 1″,

$$P = \frac{13}{40} = \cdot 325$$

Ixx of top and bottom welds = 576 (from table on page 246)

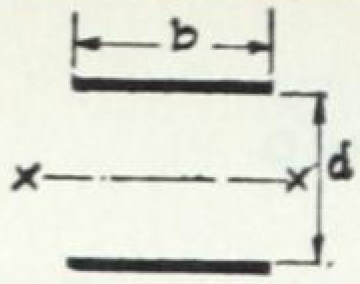
Ixx of side welds = 288 (from table on page 254)

Total Ixx of group = 864

$$B = \frac{12 \times 13 \times 6}{864} = 1 \cdot 08$$

$$R = \sqrt{1 \cdot 08^2 + \cdot 325^2} = 1 \cdot 13$$

The combined stress or load per linear inch is accordingly 1·27 tons; and from the table on page 239, we see that 5/16″ fillets are sufficient, or very nearly so. (Since the combined stress is not to exceed 5 tons per square inch, we take the safe load given for *side* welds, viz. 1·10 tons per linear inch.)



MOMENTS OF INERTIA OF WELDS

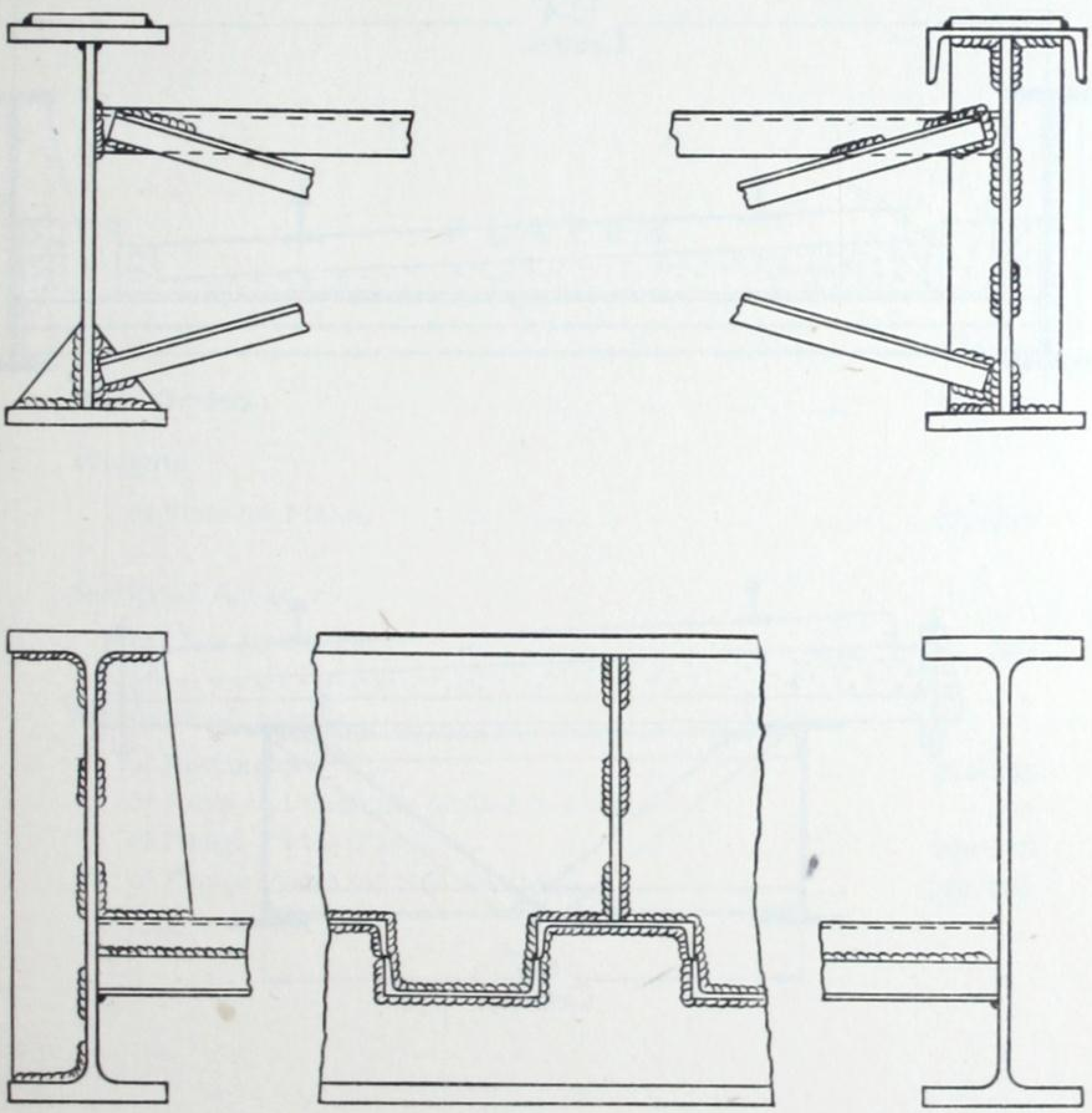
ABOUT XX AXIS FOR ONE INCH THROAT

$$I_{xx} = 2 \times t \times b \times (\tfrac{1}{2}d)^2$$

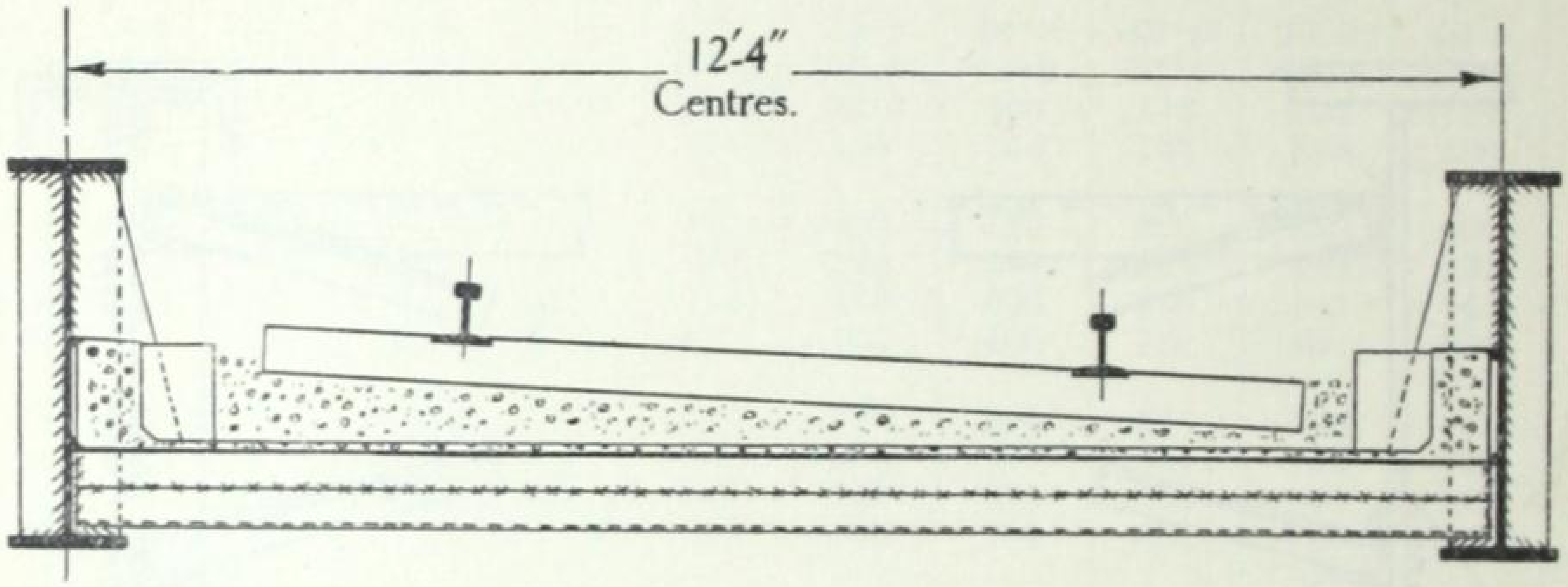
Inside depth (d) inches.	Width (b) of Welds in inches											
	1	2	3	4	5	6	7	8	9	10	11	12
	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}
3	4·5	9·0	13·5	18·0	22·5	27·0	31·5	36·0	40·5	45·0	49·5	54·0
4	8·0	16·0	24·0	32·0	40·0	48·0	56·0	64·0	72·0	80·0	88·0	96·0
5	12·5	25·0	37·5	50·0	62·5	75·0	87·5	100	112	125	137	150
6	18·0	36·0	54·0	72·0	90·0	108	126	144	162	180	198	216
7	24·5	49·0	73·5	98·0	122	147	171	196	220	245	269	294
8	32·0	64·0	96·0	128	160	192	224	256	288	320	352	384
9	40·5	81·0	121	162	202	243	283	324	364	405	445	486
10	50·0	100	150	200	250	300	350	400	450	500	550	600
11	60·5	121	181	242	302	363	423	484	544	605	665	726
12	72·0	144	216	288	360	432	504	576	648	720	792	864
13	84·5	169	253	338	423	507	591	676	760	845	929	1014
14	98·0	196	294	392	490	588	686	784	882	980	1078	1176
15	112	225	338	450	563	675	788	900	1013	1125	1238	1350
16	128	256	384	512	640	768	896	1024	1152	1280	1408	1536
17	144	289	433	578	722	867	1011	1156	1300	1445	1589	1734
18	162	324	486	648	810	972	1134	1296	1458	1620	1782	1944
19	180	361	541	722	902	1083	1263	1444	1624	1805	1985	2166
20	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
21	220	441	661	882	1102	1323	1543	1764	1984	2205	2425	2646
22	242	484	726	968	1210	1452	1694	1936	2178	2420	2662	2904
23	264	529	793	1058	1322	1587	1851	2116	2380	2645	2909	3174
24	288	576	864	1152	1440	1728	2016	2304	2592	2880	3168	3456
25	312	625	937	1250	1562	1875	2187	2500	2812	3125	3437	3750
26	338	676	1014	1352	1690	2028	2366	2704	3042	3380	3718	4056
27	364	729	1093	1458	1822	2187	2551	2916	3280	3645	4009	4374
28	392	784	1176	1568	1960	2352	2744	3136	3528	3920	4312	4704
29	420	841	1261	1682	2102	2523	2943	3364	3784	4205	4625	5046
30	450	900	1350	1800	2250	2700	3150	3600	4050	4500	4950	5400
31	480	961	1441	1922	2402	2883	3363	3844	4324	4805	5285	5766
32	512	1024	1536	2048	2560	3072	3584	4096	4608	5120	5632	6144
33	544	1089	1633	2178	2722	3267	3811	4356	4900	5445	5989	6534
34	578	1156	1734	2312	2890	3468	4046	4624	5202	5780	6358	6936
35	612	1225	1837	2450	3062	3675	4287	4900	5512	6125	6737	7350
36	648	1296	1944	2592	3240	3888	4536	5184	5832	6480	7128	7776
37	684	1369	2053	2738	3422	4107	4791	5476	6160	6845	7529	8214
38	722	1444	2166	2888	3610	4332	5054	5776	6498	7220	7942	8664
39	760	1521	2281	3042	3802	4563	5323	6084	6844	7605	8365	9126
40	800	1600	2400	3200	4000	4800	5600	6400	7200	8000	8800	9600
41	840	1681	2521	3362	4203	5043	5883	6724	7564	8405	9245	10086
42	882	1764	2646	3528	4410	5292	6174	7056	7938	8820	9702	10584

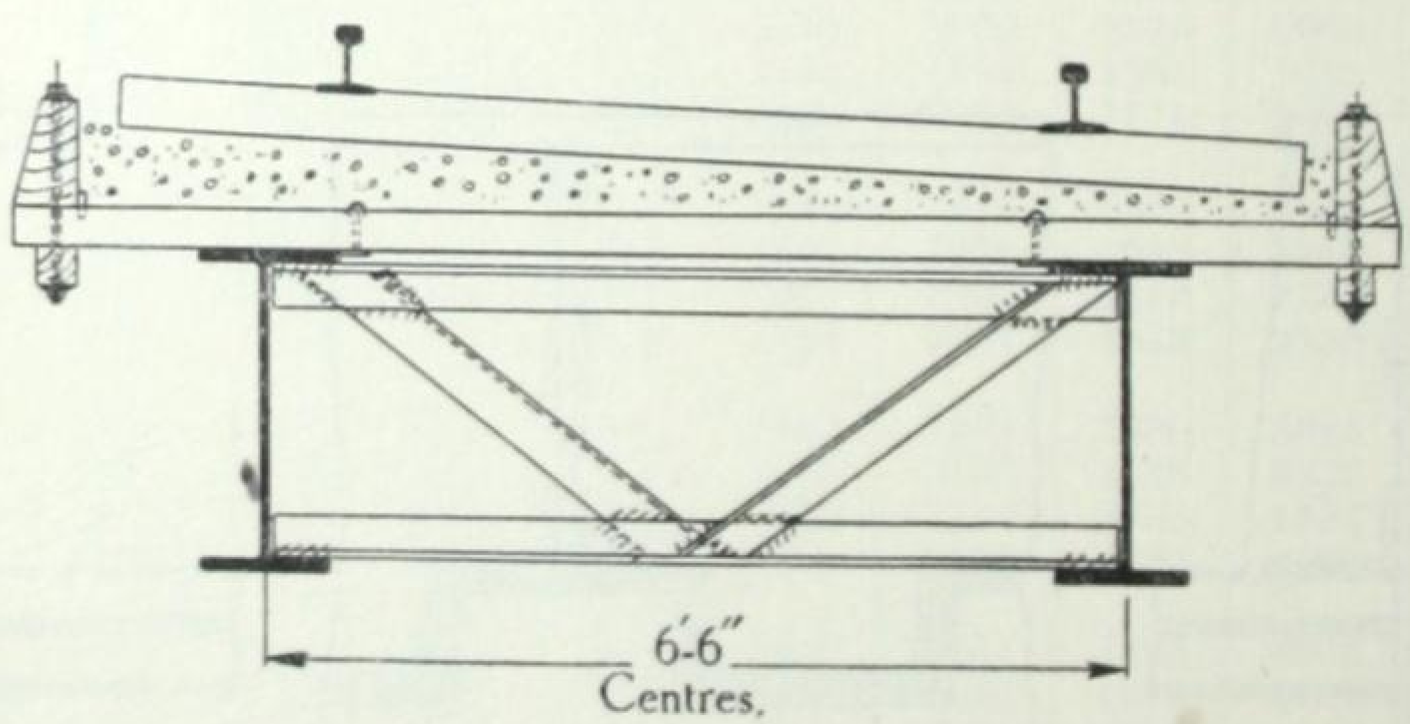
ARC WELDING IN

BRIDGE CONSTRUCTION.



For explanation, see page 248.





The drawings on this page and the lower drawing on page 247 are of a bridge, 39 feet span, over Warrigal Road on the Darling to Glenwaverley Line of the Victorian Government Railways. The main girders are Broad Flange Beams, Grey Process, 30" × 12", and the flooring comprises 15" × 4" steel channels, welded as shown.

PLATES

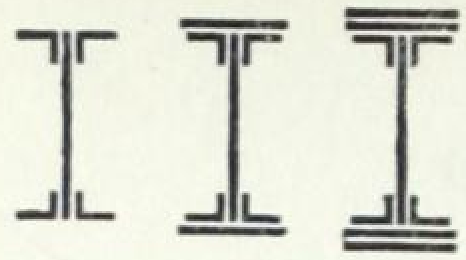
Plates, Inertia.

Tests, Extras.

Weights, Measures.

Math. tables.

Index, Code.



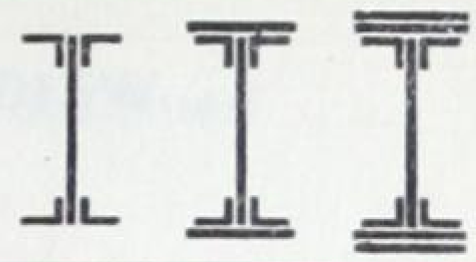
SINGLE WEB PLATE GIRDERS.

ANGLES 6″ × 4″ × 1/2″ ; FLANGE PLATES 14″ × T″.

WEB PLATE AND VARIATIONS.	NO FL. PLATES.			Flange Plates.	ONE FL. PLATE.					TWO FL. PLATES.				
	Wt. per foot & Sec. Mod.		Rivet Shear Factor		Wt. per foot & Sec. Mod.		1″ Plate width.		Rivet Shear Factor	Wt. per foot & Sec. Mod.		1″ Plate width.		Rivet Shear Factor.
	Wt.	Z_x		T	Wt.	Z_x	Z_x	Wt.		Wt.	Z_x	Z_x	Wt.	
	Lb.	Ins.^{3}		Ins.	Lb.	Ins.^{3}	Ins.^{3}	Lb.		Lb.	Ins.^{3}	Ins.^{3}	Lb.	
Web Plate, 30″ × $\frac{3}{8}$″	104	281	·114	1/2	155	431	15	3	·119	203	608	30	7	·120
,, ,, ,, ,, ...	...	...	...	5/8	167	475	19	4	·120	227	697	38	9	·120
,, ,, 30″ × $\frac{1}{2}$″	117	297	·083	1/2	168	447	15	3	·088	216	623	30	7	·089
,, ,, ,, ,, ...	...	...	...	5/8	180	491	19	4	·089	239	712	38	9	·089
Add for 6″ × 4″ × $\frac{5}{8}$″ Angles...	15	52	...	...	15	44	...	...	...	15	42	...	...	...
Deduct for 4″ × 4″ × $\frac{1}{2}$″ Angles	14	58	...	...	14	56	...	...	...	14	54	...	...	...
Add for $\frac{1}{16}$″ extra Flange thickness	...	...	...	...	6	22	...	...	...	6	22	...	...	...
,, ,, $\frac{1}{16}$″ ,, Web Do. ...	6	8	...	...	6	8	...	...	...	6	8	...	...	...
Add for 1″ Extra Depth	1	12	...	1/2	1	17	...	...	...	1	23	...	...	...
	...	...	...	5/8	1	19	...	...	...	1	26	...	...	...
	2	14	...	1/2	2	19	...	...	...	2	25	...	...	...
	...	...	...	5/8	2	20	...	...	...	2	28	...	...	...
Web Plate, 36″ × $\frac{3}{8}$″	112	355	·091	1/2	163	536	18	3	·097	211	749	36	7	·099
,, ,, ,, ,, ...	...	...	...	5/8	175	589	23	4	·097	234	856	45	9	·099
,, ,, 36″ × $\frac{1}{2}$″	127	379	·066	1/2	178	560	18	3	·071	226	772	36	7	·072
,, ,, ,, ,, ...	...	...	...	5/8	190	613	23	4	·071	250	878	45	9	·072
Add for 6″ × 4″ × $\frac{5}{8}$″ Angles...	15	64	...	...	15	55	...	...	...	15	53	...	...	...
Deduct for 4″ × 4″ × $\frac{1}{2}$″ Angles	14	70	...	...	14	68	...	...	...	14	66	...	...	...
Add for $\frac{1}{16}$″ extra Flange thickness	...	...	...	...	6	27	...	...	...	6	27	...	...	...
,, ,, $\frac{1}{16}$″ ,, Web Do. ...	7	12	...	...	7	12	...	...	...	7	11	...	...	...
Add for 1″ Extra Depth	1	13	...	1/2	1	18	...	...	...	1	24	...	...	...
	...	...	...	5/8	1	20	...	...	...	1	27	...	...	...
	2	15	...	1/2	2	20	...	...	...	2	26	...	...	...
	...	...	...	5/8	2	21	...	...	...	2	29	...	...	...
Web Plate, 42″ × $\frac{3}{8}$″	120	433	·075	1/2	171	645	21	3	·081	218	894	42	7	·083
,, ,, ,, ,, ...	...	...	...	5/8	182	707	26	4	·082	242	1019	53	9	·084
,, ,, 42″ × $\frac{1}{2}$″	138	466	·054	1/2	188	678	21	3	·059	236	926	42	7	·061
,, ,, ,, ,, ...	...	...	...	5/8	200	740	26	4	·060	260	1050	53	9	·062
Add for 6″ × 4″ × $\frac{5}{8}$″ Angles ...	15	75	...	...	15	65	...	...	...	15	63	...	...	...
Deduct for 4″ × 4″ × $\frac{1}{2}$″ Angles	14	82	...	...	14	80	...	...	...	14	78	...	...	...
Add for $\frac{1}{16}$″ extra Flange thickness	...	...	...	...	6	31	...	...	...	6	31	...	...	...
,, ,, $\frac{1}{16}$″ ,, Web Do. ...	9	16	...	...	9	16	...	...	...	9	16	...	...	...
Add for 1″ Extra Depth	1	14	...	1/2	1	19	...	...	...	1	25	...	...	...
	...	...	...	5/8	1	21	...	...	...	1	28	...	...	...
	2	16	...	1/2	2	21	...	...	...	2	27	...	...	...
	...	...	...	5/8	2	22	...	...	...	2	30	...	...	...

SINGLE WEB PLATE GIRDERS.—Continued.

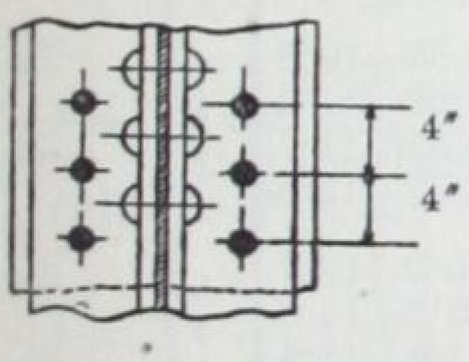
ANGLES 6″ × 4″ × 1/2″ ; FLANGE PLATES 14″ × T″



WEB PLATE AND VARIATIONS.	NO FL. PLATES.			Flange Plates.	ONE FL. PLATE.					TWO FL. PLATES.				
	Wt. per foot & Sec. Mod.		Rivet Shear Factor		Wt. per foot & Sec. Mod.		1″ Plate width.		Rivet Shear Factor	Wt. per foot & Sec. Mod.		1″ Plate width.		Rivet Shear Factor
	Wt.	Z_x		T	Wt.	Z_x	Z_x	Wt.		Wt.	Z_x	Z_x	Wt.	
	Lb.	Ins.³		Ins.	Lb.	Ins.³	Ins.³	Lb.		Lb.	Ins.³	Ins.³	Lb.	
Web Plate, 48″ × ⅜″	127	517	·062	1/2	178	761	24	3	·069	226	1046	48	7	·072
,, ,, ,, ,, ...	...	...	...	5/8	190	832	30	4	·070	250	1188	60	9	·072
,, ,, 48″ × ½″	148	561	·041	1/2	199	804	24	3	·050	246	1088	48	7	·052
,, ,, ,, ,, ...	...	...	...	5/8	211	875	30	4	·051	270	1230	60	9	·053
Add for 6″ × 4″ × ⅝″ Angles ...	15	87	...	...	15	76	...	...	...	15	74	...	...	...
Deduct for 4″ × 4″ × ½″ Angles	14	94	...	...	14	92	...	...	...	14	90	...	...	...
Add for 1/16″ extra Flange thickness	...	...	...	...	6	36	...	...	...	6	36	...	...	...
,, ,, 1/16″ ,, Web Do. ...	10	21	...	...	10	21	...	...	...	10	21	...	..	...

EXPLANATION OF TABLE.

The above table gives the properties of plate girders of the three types illustrated, viz. :—
(i) without flange plates, (ii) with one flange plate, (iii) with two flange plates, on each flange, respectively. The properties tabulated are for 14″ flange plates of various thicknesses (T).



For plates other than 14″ wide, the variations in weight and modulus can be ascertained by using the figures headed *1″ plate width.*

WEIGHTS AND RIVETS. 3/4″ rivets at 4″ pitch are assumed (see figure), *i.e.*, 36 or 12 heads per foot run, with or without flange plates respectively.

STIFFENERS. These are not included in the weights. For notes, see page 58.

SECTION MODULI. These are nett, deductions having been made for three or one holes in each flange, with or without flange plates respectively, 1/8″ more metal than the diameter of the rivet being assumed out of action.

The following relation is useful for all symmetrically plated sections :—

The required area of the plates on each flange equals the difference between (i) *the required section modulus* ÷ *original depth, and* (ii) *original section modulus* ÷ *final depth.*

The values taken for areas and moduli must, of course, be the nett values after deducting for rivet holes.

RIVET SHEAR FACTOR, PITCH OF RIVETS, ETC. The number of rivets per foot run in each flange required to connect the web to the flange angles is found by multiplying the vertical shear in tons by the tabulated factor. For derivation, see page 60, §2.
This method gives a greater pitch than that given by the common but less exact formula : vertical shear × pitch = shear or bearing value of one rivet × vertical distance between the rivets. When the rivets have to carry a superimposed load in addition to coping with the horizontal shear, the number of rivets required will be the square root of the sum of the squares of (i) the number required by the last paragraph, and (ii) the number required for the load.
The pitch so obtained should not exceed in the compression flange 16 times the thickness of the thinnest metal.

STOPPING OFF OF PLATES. Having found the required section, the section modulus with one plate less can be ascertained from the table, and the position of the point in the girder where the bending moment divided by the working stress equals this reduced value, found graphically or by calculation on the principles described on page 49. It is usual to extend the plates 2 or 3 pitches beyond the theoretical points.

BROAD FLANGE BEAMS, GREY PROCESS. Many of the built-up girders tabulated above can be replaced with advantage by a plain Broad Flange Beam ; see Summary of Sections, page 43.

Tests, Extras.
Weights, Measures
Math. tables.
Index, Code.

WEIGHTS OF STEEL FLATS—OR PLATES.

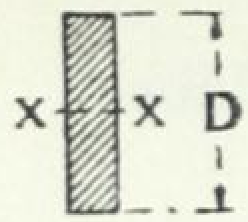
IN POUNDS PER FOOT RUN.

Width (Inches).	THICKNESS (Inches).												Width (Inches).
	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1-1/4	
1/2	·212	·319	·425	·531	·637	·744	·850	1·06	1·27	1·49	1·70	2·12	1/2
5/8	·266	·398	·531	·664	·797	·930	1·06	1·33	1·59	1·86	2·12	2·66	5/8
3/4	·319	·478	·637	·797	·956	1·12	1·27	1·59	1·91	2·23	2·55	3·19	3/4
7/8	·372	·558	·744	·930	1·12	1·30	1·49	1·86	2·23	2·60	2·97	3·72	7/8
1	·425	·638	·850	1·06	1·27	1·49	1·70	2·12	2·55	2·97	3·40	4·25	1
1⅛	·478	·717	·956	1·20	1·43	1·67	1·91	2·39	2·87	3·35	3·82	4·78	1⅛
1¼	·531	·797	1·06	1·33	1·59	1·86	2·12	2·66	3·19	3·72	4·25	5·31	1¼
1⅜	·584	·877	1·17	1·46	1·75	2·04	2·34	2·92	3·51	4·09	4·67	5·84	1⅜
1½	·637	·956	1·27	1·59	1·91	2·23	2·55	3·19	3·82	4·46	5·10	6·37	1½
1⅝	·691	1·04	1·38	1·73	2·07	2·42	2·76	3·45	4·14	4·83	5·53	6·91	1⅝
1¾	·744	1·12	1·49	1·86	2·23	2·60	2·97	3·72	4·46	5·21	5·95	7·44	1¾
1⅞	·797	1·19	1·59	1·99	2·39	2·79	3·19	3·98	4·78	5·58	6·38	7·97	1⅞
2	·850	1·27	1·70	2·12	2·55	2·97	3·40	4·25	5·10	5·95	6·80	8·50	2
2⅛	·903	1·35	1·81	2·26	2·71	3·16	3·61	4·52	5·42	6·32	7·22	9·03	2⅛
2¼	·956	1·43	1·91	2·39	2·87	3·35	3·82	4·78	5·74	6·69	7·65	9·56	2¼
2⅜	1·01	1·51	2·02	2·52	3·03	3·53	4·04	5·05	6·06	7·07	8·07	10·1	2⅜
2½	1·06	1·59	2·12	2·66	3·19	3·72	4·25	5·31	6·37	7·44	8·50	10·6	2½
2⅝	1·12	1·67	2·23	2·79	3·35	3·90	4·46	5·58	6·69	7·81	8·92	11·2	2⅝
2¾	1·17	1·75	2·34	2·92	3·51	4·09	4·67	5·84	7·01	8·18	9·35	11·7	2¾
2⅞	1·22	1·83	2·44	3·05	3·67	4·28	4·89	6·11	7·33	8·55	9·77	12·2	2⅞
3	1·27	1·91	2·55	3·19	3·82	4·46	5·10	6·37	7·65	8·92	10·2	12·7	3
3⅛	1·33	1·99	2·66	3·32	3·98	4·65	5·31	6·64	7·97	9·30	10·6	13·3	3⅛
3¼	1·38	2·07	2·76	3·45	4·14	4·83	5·52	6·91	8·29	9·67	11·0	13·8	3¼
3⅜	1·43	2·15	2·87	3·59	4·30	5·02	5·74	7·17	8·61	10·0	11·5	14·3	3⅜
3½	1·49	2·23	2·97	3·72	4·46	5·21	5·95	7·44	8·92	10·4	11·9	14·9	3½
3⅝	1·54	2·31	3·08	3·85	4·62	5·39	6·16	7·70	9·24	10·8	12·3	15·4	3⅝
3¾	1·59	2·39	3·19	3·98	4·78	5·58	6·37	7·97	9·56	11·2	12·7	15·9	3¾
3⅞	1·65	2·47	3·29	4·12	4·94	5·76	6·59	8·23	9·88	11·5	13·2	16·5	3⅞
4	1·70	2·55	3·40	4·25	5·10	5·95	6·80	8·50	10·2	11·9	13·6	17·0	4
4⅛	1·75	2·63	3·51	4·38	5·26	6·14	7·01	8·77	10·5	12·3	14·0	17·5	4⅛
4¼	1·81	2·71	3·61	4·52	5·42	6·32	7·22	9·03	10·8	12·6	14·4	18·1	4¼
4⅜	1·86	2·79	3·72	4·65	5·58	6·51	7·44	9·30	11·2	13·0	14·9	18·6	4⅜
4½	1·91	2·87	3·82	4·78	5·74	6·69	7·65	9·56	11·5	13·4	15·3	19·1	4½
4⅝	1·97	2·95	3·93	4·91	5·90	6·88	7·86	9·83	11·8	13·8	15·7	19·7	4⅝
4¾	2·02	3·03	4·04	5·05	6·06	7·07	8·07	10·1	12·1	14·1	16·1	20·2	4¾
4⅞	2·07	3·11	4·14	5·18	6·22	7·25	8·29	10·4	12·4	14·5	16·6	20·7	4⅞
5	2·12	3·19	4·25	5·31	6·37	7·44	8·50	10·6	12·7	14·9	17·0	21·2	5
5⅛	2·18	3·27	4·36	5·44	6·53	7·62	8·71	10·9	13·1	15·2	17·4	21·8	5⅛
5¼	2·23	3·35	4·46	5·58	6·69	7·81	8·92	11·2	13·4	15·6	17·8	22·3	5¼
5⅜	2·28	3·43	4·57	5·71	6·85	7·99	9·14	11·4	13·7	16·0	18·3	22·8	5⅜
5½.	2·34	3·51	4·67	5·84	7·01	8·18	9·35	11·7	14·0	16·4	18·7	23·4	5½
5⅝	2·39	3·59	4·78	5·98	7·17	8·37	9·56	12·0	14·3	16·7	19·1	23·9	5⅝
5¾	2·44	3·67	4·89	6·11	7·33	8·55	9·77	12·2	14·7	17·1	19·5	24·4	5¾
5⅞	2·50	3·74	4·99	6·24	7·49	8·74	9·99	12·5	15·0	17·5	20·0	25·0	5⅞
6	2·55	3·82	5·10	6·37	7·65	8·92	10·2	12·7	15·3	17·8	20·4	25·5	6

WEIGHTS OF STEEL FLATS (OR PLATES)—Continued.

IN POUNDS PER FOOT RUN.

Width (Inches)	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1-1/4	Width (Inches).
	THICKNESS (Inches).												
6	2·55	3·82	5·10	6·37	7·65	8·92	10·2	12·7	15·3	17·8	20·4	25·5	6
6¼	2·66	3·98	5·31	6·64	7·97	9·30	10·6	13·3	15·9	18·6	21·2	26·6	6¼
6½	2·76	4·14	5·52	6·91	8·29	9·67	11·0	13·8	16·6	19·3	22·1	27·6	6½
6¾	2·87	4·30	5·74	7·17	8·61	10·0	11·5	14·3	17·2	20·1	22·9	28·7	6¾
7	2·97	4·46	5·95	7·44	8·92	10·4	11·9	14·9	17·8	20·8	23·8	29·7	7
7¼	3·08	4·62	6·16	7·70	9·24	10·8	12·3	15·4	18·5	21·6	24·6	30·8	7¼
7½	3·19	4·78	6·37	7·97	9·56	11·2	12·7	15·9	19·1	22·3	25·5	31·9	7½
7¾	3·29	4·94	6·59	8·23	9·88	11·5	13·2	16·5	19·8	23·1	26·3	32·9	7¾
8	3·40	5·10	6·80	8·50	10·2	11·9	13·6	17·0	20·4	23·8	27·2	34·0	8
8¼	3·51	5·26	7·01	8·77	10·5	12·3	14·0	17·5	21·0	24·5	28·0	35·1	8¼
8½	3·61	5·42	7·22	9·03	10·8	12·6	14·4	18·1	21·7	25·3	28·9	36·1	8½
8¾	3·72	5·58	7·44	9·30	11·2	13·0	14·9	18·6	22·3	26·0	29·7	37·2	8¾
9	3·82	5·74	7·65	9·56	11·5	13·4	15·3	19·1	22·9	26·8	30·6	38·2	9
9¼	3·93	5·90	7·86	9·83	11·8	13·8	15·7	19·7	23·6	27·5	31·4	39·3	9¼
9½	4·04	6·06	8·07	10·1	12·1	14·1	16·1	20·2	24·2	28·3	32·3	40·4	9½
9¾	4·14	6·22	8·29	10·4	12·4	14·5	16·6	20·7	24·9	29·0	33·1	41·4	9¾
10	4·25	6·37	8·50	10·6	12·7	14·9	17·0	21·2	25·5	29·7	34·0	42·5	10
10¼	4·36	6·53	8·71	10·9	13·1	15·2	17·4	21·8	26·1	30·5	34·8	43·6	10¼
10½	4·46	6·69	8·92	11·2	13·4	15·6	17·8	22·3	26·8	31·2	35·7	44·6	10½
10¾	4·57	6·85	9·14	11·4	13·7	16·0	18·3	22·8	27·4	32·0	36·5	45·7	10¾
11	4·67	7·01	9·35	11·7	14·0	16·4	18·7	23·4	28·0	32·7	37·4	46·7	11
11¼	4·78	7·17	9·56	12·0	14·3	16·7	19·1	23·9	28·7	33·5	38·2	47·8	11¼
11½	4·89	7·33	9·77	12·2	14·7	17·1	19·5	24·4	29·3	34·2	39·1	48·9	11½
11¾	4·99	7·49	9·99	12·5	15·0	17·5	20·0	25·0	30·0	35·0	39·9	49·9	11¾
12	5·10	7·65	10·2	12·7	15·3	17·8	20·4	25·5	30·6	35·7	40·8	51·0	12
12½	5·31	7·97	10·6	13·3	15·9	18·6	21·2	26·6	31·9	37·2	42·5	53·1	12½
13	5·53	8·29	11·0	13·8	16·6	19·3	22·1	27·6	33·1	38·7	44·2	55·2	13
13½	5·74	8·61	11·5	14·3	17·2	20·1	22·9	28·7	34·4	40·2	45·9	57·4	13½
14	5·95	8·93	11·9	14·9	17·8	20·8	23·8	29·7	35·7	41·6	47·6	59·5	14
14½	6·16	9·24	12·3	15·4	18·5	21·6	24·6	30·8	37·0	43·1	49·3	61·6	14½
15	6·38	9·56	12·7	15·9	19·1	22·3	25·5	31·9	38·2	44·6	51·0	63·7	15
15½	6·59	9·88	13·2	16·5	19·8	23·1	26·3	32·9	39·5	46·1	52·7	65·9	15½
16	6·80	10·2	13·6	17·0	20·4	23·8	27·2	34·0	40·8	47·6	54·4	68·0	16
17	7·23	10·8	14·4	18·1	21·7	25·3	28·9	36·1	43·3	50·6	57·8	72·2	17
18	7·65	11·5	15·3	19·1	22·9	26·8	30·6	38·2	45·9	53·5	61·2	76·5	18
19	8·08	12·1	16·1	20·2	24·2	28·3	32·3	40·4	48·4	56·5	64·6	80·7	19
20	8·50	12·7	17·0	21·2	25·5	29·7	34·0	42·5	51·0	59·5	68·0	85·0	20
22	9·35	14·0	18·7	23·4	28·0	32·7	37·4	46·7	56·1	65·4	74·8	93·5	22
24	10·2	15·3	20·4	25·5	30·6	35·7	40·8	51·0	61·2	71·4	81·6	102·0	24
26	11·0	16·6	22·1	27·6	33·1	38·7	44·2	55·2	66·3	77·3	88·4	110·5	26
28	11·9	17·8	23·8	29·7	35·7	41·6	47·6	59·5	71·4	83·3	95·2	119·0	28
30	12·7	19·1	25·5	31·9	38·2	44·6	51·0	63·7	76·5	89·2	102·0	127·5	30
32	13·6	20·4	27·2	34·0	40·8	47·6	54·4	68·0	81·6	95·2	108·8	136·0	32
34	14·4	21·7	28·9	36·1	43·3	50·6	57·8	72·2	86·7	101·1	115·6	144·5	34
36	15·3	22·9	30·6	38·2	45·9	53·5	61·2	76·5	91·8	107·1	122·4	153·0	36



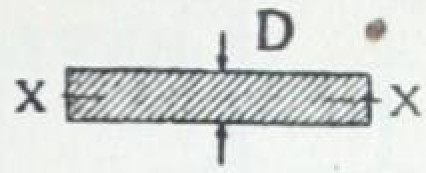
MOMENTS OF INERTIA OF RECTANGLES.

VERTICAL.

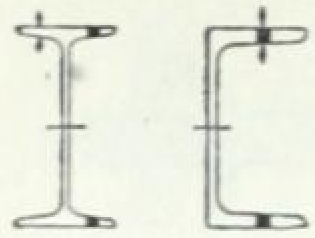
Depth (Inches).	WIDTH (Inches). 1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	Depth. (Inches)
1	·021	·026	·031	·036	·042	·047	·052	·057	·062	·073	·083	1
2	·167	·208	·250	·292	·333	·375	·417	·458	·500	·583	·667	2
3	·562	·703	·844	·984	1·13	1·27	1·41	1·55	1·69	1·97	2·25	3
4	1·33	1·67	2·00	2·33	2·67	3·00	3·33	3·67	4·00	4·67	5·33	4
5	2·60	3·26	3·91	4·56	5·21	5·86	6·51	7·16	7·81	9·11	10·4	5
6	4·50	5·63	6·75	7·88	9·00	10·1	11·2	12·4	13·5	15·7	18·0	6
7	7·15	8·93	10·7	12·5	14·3	16·1	17·9	19·6	21·4	25·0	28·6	7
8	10·7	13·3	16·0	18·7	21·3	24·0	26·7	29·3	32·0	37·3	42·7	8
9	15·2	19·0	22·8	26·6	30·4	34·2	38·0	41·8	45·6	53·2	60·7	9
10	20·8	26·0	31·2	36·5	41·7	46·9	52·1	57·3	62·5	72·9	83·3	10
11	27·7	34·7	41·6	48·5	55·5	62·4	69·3	76·3	83·2	97·0	111	11
12	36·0	45·0	54·0	63·0	72·0	81·0	90·1	99·0	108	126	144	12
13	45·8	57·2	68·7	80·1	91·5	103	114	126	137	160	183	13
14	57·2	71·5	85·7	100	114	129	143	157	171	200	229	14
15	70·3	87·9	105	123	141	158	176	193	211	246	281	15
16	85·3	107	128	149	171	192	213	235	256	299	341	16
17	102	128	154	179	205	230	256	281	307	358	409	17
18	121	152	182	213	243	273	304	334	364	425	486	18
19	143	179	214	250	286	322	357	393	429	500	572	19
20	167	208	250	292	333	375	417	458	500	583	667	20
21	193	241	289	338	386	434	482	531	579	675	772	21
22	222	277	333	388	444	499	555	610	665	776	887	22
23	253	317	380	444	507	570	634	697	760	887	1014	23
24	288	360	432	504	576	648	720	792	864	1008	1152	24
25	326	407	488	570	651	732	814	895	977	1139	1302	25
26	366	458	549	641	732	824	915	1007	1098	1282	1465	26
27	410	513	615	718	820	923	1025	1128	1230	1435	1640	27
28	457	572	686	800	915	1029	1143	1258	1372	1601	1829	28
29	508	635	762	889	1016	1143	1270	1397	1524	1778	2032	29
30	562	703	844	984	1125	1266	1406	1547	1687	1969	2250	30
32	683	853	1024	1195	1365	1536	1707	1877	2048	2389	2731	32
34	819	1024	1228	1433	1638	1842	2047	2252	2456	2866	3275	34
36	972	1215	1458	1701	1944	2187	2430	2673	2916	3402	3888	36
38	1143	1429	1715	2001	2286	2572	2858	3144	3429	4001	4573	38
40	1333	1667	2000	2333	2667	3000	3333	3667	4000	4667	5333	40
42	1543	1929	2315	2701	3087	3473	3859	4245	4630	5402	6174	42
44	1775	2218	2662	3106	3549	3993	4437	4880	5324	6211	7099	44
46	2028	2535	3042	3549	4056	4563	5070	5577	6083	7097	8111	46
48	2304	2880	3456	4032	4608	5184	5760	6336	6912	8064	9216	48
50	2604	3255	3906	4557	5208	5859	6510	7161	7812	9115	10417	50
52	2929	3662	4394	5126	5859	6591	7323	8056	8788	10253	11717	52
54	3280	4101	4921	5741	6561	7381	8201	9021	9841	11482	13122	54
56	3659	4573	5488	6403	7317	8232	9147	10061	10976	12805	14635	56
58	4065	5081	6097	7113	8130	9146	10162	11178	12194	14227	16259	58
60	4500	5625	6750	7875	9000	10125	11250	12375	13500	15750	18000	60

MOMENTS OF INERTIA OF RECTANGLES.

HORIZONTAL.



Depth (Inches).		WIDTH (Inches). 8	9	10	12	14	16	18	20	24	Depth (Inches).	
3/8	...	·035	·040	·044	·053	·062	·070	·079	·088	·105	3/8	
	7/16	·056	·063	·070	·084	·098	·112	·126	·140	·167	...	7/16
1/2	...	·083	·094	·104	·125	·146	·167	·187	·208	·250	1/2	
	9/16	·119	·133	·148	·178	·208	·237	·267	·297	·356	...	9/16
5/8	...	·163	·183	·203	·244	·285	·326	·366	·407	·488	5/8	
	11/16	·217	·244	·271	·325	·379	·433	·487	·542	·650	...	11/16
3/4	...	·281	·316	·352	·422	·492	·562	·633	·703	·844	3/4	
	13/16	·358	·402	·447	·536	·626	·715	·805	·894	1·07	...	13/16
7/8	...	·447	·502	·558	·670	·782	·893	1·00	1·12	1·34	7/8	
	15/16	·549	·618	·687	·824	·961	1·10	1·24	1·37	1·65	...	15/16
1	...	·667	·750	·833	1·00	1·17	1·33	1·50	1·67	2·00	1	
	1 1/16	·800	·900	1·00	1·20	1·40	1·60	1·80	2·00	2·40	...	1 1/16
1 1/8	...	·949	1·07	1·19	1·42	1·66	1·90	2·14	2·37	2·85	1 1/8	
	1 3/16	1·12	1·26	1·39	1·67	1·95	2·23	2·51	2·79	3·35	...	1 3/16
1 1/4	...	1·30	1·46	1·63	1·95	2·28	2·60	2·93	3·25	3·91	1 1/4	
	1 5/16	1·51	1·70	1·88	2·26	2·64	3·01	3·39	3·77	4·52	...	1 5/16
1 3/8	...	1·73	1·95	2·17	2·60	3·03	3·47	3·90	4·33	5·20	1 3/8	
	1 7/16	1·98	2·23	2·47	2·97	3·47	3·96	4·46	4·95	5·94	...	1 7/16
1 1/2	...	2·25	2·53	2·81	3·37	3·94	4·50	5·06	5·62	6·75	1 1/2	
	1 9/16	2·54	2·86	3·18	3·81	4·45	5·09	5·72	6·36	7·63	...	1 9/16
1 5/8	...	2·86	3·22	3·58	4·29	5·01	5·72	6·44	7·15	8·58	1 5/8	
	1 11/16	3·20	3·60	4·01	4·80	5·61	6·41	7·21	8·01	9·61	...	1 11/16
1 3/4	...	3·57	4·02	4·47	5·36	6·25	7·15	8·04	8·93	10·72	1 3/4	
	1 13/16	3·97	4·47	4·96	5·95	6·95	7·94	8·93	9·92	11·91	...	1 13/16
1 7/8	...	4·39	4·94	5·49	6·59	7·69	8·79	9·89	10·99	13·18	1 7/8	
	1 15/16	4·85	5·45	6·06	7·27	8·48	9·70	10·91	12·12	14·55	...	1 15/16
2	...	5·33	6·00	6·67	8·00	9·33	10·67	12·00	13·33	16·00	2	
	2 1/16	5·85	6·58	7·31	8·77	10·24	11·70	13·16	14·62	17·55	...	2 1/16
2 1/8	...	6·40	7·20	8·00	9·60	11·19	12·79	14·39	15·99	19·19	2 1/8	
	2 3/16	6·98	7·85	8·72	10·47	12·21	13·96	15·70	17·45	20·93	...	2 3/16
2 1/4	...	7·59	8·54	9·49	11·39	13·29	15·19	17·09	18·98	22·78	2 1/4	
	2 5/16	8·24	9·27	10·30	12·37	14·43	16·49	18·55	20·61	24·73	...	2 5/16
2 3/8	...	8·93	10·05	11·16	13·40	15·63	17·86	20·09	22·33	26·79	2 3/8	
	2 7/16	9·65	10·86	12·07	14·48	16·90	19·31	21·72	24·14	28·96	...	2 7/16
2 1/2	...	10·42	11·72	13·02	15·62	18·23	20·83	23·44	26·04	31·25	2 1/2	
	2 5/8	12·06	13·57	15·07	18·09	21·10	24·12	27·13	30·15	36·18	...	2 5/8
2 3/4	...	13·86	15·60	17·33	20·80	24·26	27·73	31·19	34·66	41·59	2 3/4	
	2 7/8	15·84	17·82	19·80	23·76	27·72	31·68	35·65	39·61	47·53	...	2 7/8
3	...	18·00	20·25	22·50	27·00	31·50	36·00	40·50	45·00	54·00	3	



MOMENTS OF INERTIA

OF JOISTS AND CHANNELS DRILLED FOR FLANGE PLATES.

British Standard Sections, 1932 Series.

Joist.		Mean Flange Thickness.	Moments of Inertia.			Assumed Diameter.		Channel.		Mean Flange Thickness.	Moments of Inertia.			Assumed Diameter.	
			1" Holes.	Joist.							1" Holes.	Channel.			
d × b	Wt.	T		Gross.	Nett.	Hole.	Rivet.	d × b	Wt.	T		Gross.	Nett.	Hole.	Rivet.
Ins.	Lb.	Ins.	Ins.⁴	Ins.⁴	Ins.⁴	Ins.	Ins.	Ins.	Lb.	Ins.	Ins.⁴	Ins.⁴	Ins.⁴	Ins.	Ins
3 × 1½	4	·249	·942	1·66	...	...	...	**3×1½**	4·60	·28	1·04	1·82	...	...	...
3 × 3	8½	·332	1·19	3·81	...	...	...	,,	5·11	·28	,,	1·94	...	...	...
4 × 1¾	5	·239	1·69	3·66	...	...	...	**4×2**	7·09	·31	2·11	5·06	3·61	11/16	5/8
4 × 3	10	·347	2·32	7·79	...	...	...	,,	7·91	·31	,,	5·38	3·93	,,	,,
4¾ × 1¾	6½	·325	3·19	6·73	...	...	...	**5×2½**	10·2	·38	4·06	11·9	8·58	13/16	3/4
5 × 3	11	·376	4·03	13·7	...	...	...	,,	11·2	·38	,,	12·5	9·20	,,	,,
5 × 4½	20	·513	5·17	25·0	21·5	11/16	5/8	**6×3**	12·4	·38	6·00	21·3	16·4	,,	,,
6 × 3	12	·377	5·96	21·0	...	...	...	,,	13·6	·38	,,	22·3	17·4	,,	,,
6 × 4½	20	·431	6·70	34·7	30·1	11/16	5/8	**6×3**	16·5	·48	7·31	26·3	20·4	,,	,,
6 × 5	25	·520	7·83	43·7	37·3	13/16	3/4	,,	17·5	·48	,,	27·2	21·3	,,	,,
7 × 4	16	·387	8·47	39·5	33·7	11/16	5/8	**6×3½**	16·5	·48	,,	28·9	22·9	,,	,,
8 × 4	18	·398	11·5	55·6	47·7	,,	,,	,,	18·5	·48	,,	30·7	24·8	,,	,,
8 × 5	28	·575	15·9	89·7	76·8	13/16	3/4	**7×3**	14·2	·42	9·09	32·7	25·4	,,	,,
8 × 6	35	·648	17·5	115	101	,,	,,	,,	17·1	·42	,,	36·2	28·8	,,	,,
9 × 4	21	·457	16·7	81·1	69·7	11/16	5/8	**7×3½**	18·3	·50	10·6	42·8	34·3	,,	,,
9 × 7	50	·825	27·6	208	182	15/16	7/8	,,	20·2	·50	,,	45·1	36·5	,,	,,
10 × 4½	25	·505	22·8	122	104	13/16	3/4	**8×3**	16·0	·44	12·6	46·7	36·5	,,	,,
10 × 5	30	·552	24·7	146	126	,,	,,	,,	18·7	·44	,,	51·0	40·8	,,	,,
10 × 6	40	·709	30·6	205	180	,,	,,	**8×3½**	20·2	·52	14·5	60·6	48·8	,,	,,
10 × 8	55	·783	33·3	289	258	15/16	7/8	,,	23·2	·52	,,	65·3	53·5	,,	,,
12 × 5	32	·550	36·1	221	192	13/16	3/4	**9×3**	17·5	·44	16·1	62·5	49·4	,,	,,
12 × 6	44	·717	45·6	317	280	,,	,,	,,	19·9	·44	,,	67·4	54·3	,,	,,
12 × 6	54	·883	54·8	376	331	,,	,,	**9×3½**	22·3	·54	19·3	82·6	66·9	,,	,,
12 × 8	65	·904	55·7	488	436	15/16	7/8	,,	23·5	·54	,,	85·1	69·4	,,	,,
13 × 5	35	·604	46·4	284	246	13/16	3/4	,,	25·6	·54	,,	89·3	73·6	,,	,,
14 × 6	46	·698	62·0	443	393	,,	,,	**10×3**	19·3	·45	20·5	82·7	66·0	,,	,,
14 × 6	57	·873	75·3	533	472	,,	,,	,,	21·3	·45	,,	87·7	71·0	,,	,,
14 × 8	70	·920	78·7	706	632	15/16	7/8	**10×3½**	24·5	·56	25·0	110	89·2	,,	,,
15 × 5	42	·647	66·5	428	374	13/16	3/4	,,	28·5	·56	,,	120	99·7	,,	,,
15 × 6	45	·655	67·4	492	429	15/16	7/8	**11×3½**	26·8	·58	31·5	142	116	,,	,,
16 × 6	50	·726	84·7	618	539	,,	,,	,,	30·5	·58	,,	153	127	,,	,,
16 × 6	62	·847	97·1	725	634	,,	,,	**12×3½**	26·4	·50	33·1	160	132	,,	,,
16 × 8	75	·938	106	974	874	,,	,,	,,	30·4	·50	,,	174	147	,,	,,
18 × 6	55	·757	113	842	736	,,	,,	**12×4**	31·3	·60	39·0	200	168	,,	,,
18 × 7	75	·928	136	1151	1023	,,	,,	,,	36·6	·60	,,	219	187	,,	,,
18 × 8	80	·950	138	1292	1163	,,	,,	**15×4**	36·4	·62	64·1	349	289	15/16	7/8
20 × 6½	65	·820	151	1226	1085	,,	,,	,,	42·5	·62	,,	383	323	,,	,,
20 × 7½	89	1·01	182	1673	1502	,,	,,	**17×4**	44·3	·68	90·6	520	435	,,	,,
22 × 7	75	·834	187	1677	1502	,,	,,	,,	51·3	·68	,,	569	484	,,	,,
24 × 7½	95	1·01	267	2533	2283	,,	,,								

1. For Moments of Inertia of Plates top and bottom, see pages 258 to 261.
2. The Moment of Inertia of holes 1" wide is given to enable that for any diameter of hole to be easily calculated.
3. The depth of the hole is assumed to be the mean flange thickness as tabulated.

SECTIONAL AREAS OF FLATS—OR PLATES.

IN SQUARE INCHES.

Width (Inches).	THICKNESS (Inches).										
	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	2
1/2	·094	·125	·156	·187	·219	...	...	...	...	...	...
5/8	·117	·156	·195	·234	·273	·312	...	...	...	...	...
3/4	·141	·187	·234	·281	·328	·375	·469	...	...	...	...
7/8	·164	·219	·273	·328	·383	·437	·547	·656	...	...	...
1	·187	·250	·312	·375	·437	·500	·625	·750	·875	...	...
1¼	·234	·312	·391	·469	·547	·625	·781	·937	1·09	1·25	...
1½	·281	·375	·469	·562	·656	·750	·937	1·12	1·31	1·50	...
1¾	·328	·437	·547	·656	·766	·875	1·09	1·31	1·53	1·75	...
2	·375	·500	·625	·750	·875	1·00	1·25	1·50	1·75	2·00	...
2½	·469	·625	·781	·937	1·09	1·25	1·56	1·87	2·19	2·50	...
3	·562	·750	·937	1·12	1·31	1·50	1·87	2·25	2·62	3·00	6·0
3½	·656	·875	1·09	1·31	1·53	1·75	2·19	2·62	3·06	3·50	7·0
4	·750	1·00	1·25	1·50	1·75	2·00	2·50	3·00	3·50	4·00	8·0
4½	·844	1·12	1·41	1·69	1·97	2·25	2·81	3·37	3·94	4·50	9·0
5	·937	1·25	1·56	1·87	2·19	2·50	3·12	3·75	4·37	5·00	10·0
5½	1·03	1·37	1·72	2·06	2·41	2·75	3·44	4·12	4·81	5·50	11·0
6	1·12	1·50	1·87	2·25	2·62	3·00	3·75	4·50	5·25	6·00	12·0
6½	...	...	...	2·44	2·84	3·25	4·06	4·87	5·69	6·50	13·0
7	...	...	...	2·62	3·06	3·50	4·37	5·25	6·12	7·00	14·0
8	...	...	...	3·00	3·50	4·00	5·00	6·00	7·00	8·00	16·0
9	...	...	...	3·37	3·94	4·50	5·62	6·75	7·87	9·00	18·0
10	...	...	...	3·75	4·37	5·00	6·25	7·50	8·75	10·0	20·0
11	...	...	...	...	4·81	5·50	6·87	8·25	9·62	11·0	22·0
12	...	...	...	...	5·25	6·00	7·50	9·00	10·50	12·0	24·0
14	...	...	...	...	6·12	7·00	8·75	10·50	12·25	14·0	28·0
16	...	...	...	...	...	8·00	10·00	12·00	14·00	16·0	32·0
18	...	...	...	...	...	9·00	11·25	13·50	15·75	18·0	36·0
21	...	...	...	...	...	10·50	13·12	15·75	18·37	21·0	42·0
24	...	...	...	...	...	12·00	15·00	18·00	21·00	24·0	48·0
7/16	·082	·109	·137	·164	·191	·219	·273	·328	·383	·437	·875
1/2	·094	·125	·156	·187	·219	·250	·312	·375	·437	·500	1·000
9/16	·105	·141	·176	·211	·246	·281	·352	·422	·492	·562	1·125
5/8	·117	·156	·195	·234	·273	·312	·391	·469	·547	·625	1·250
11/16	·129	·172	·215	·258	·301	·344	·430	·516	·602	·687	1·375
3/4	·141	·187	·234	·281	·328	·375	·469	·562	·656	·750	1·500
13/16	·152	·203	·254	·305	·355	·406	·508	·609	·711	·812	1·625
7/8	·164	·219	·273	·328	·383	·437	·547	·656	·766	·875	1·750
15/16	·176	·234	·293	·352	·410	·469	·586	·703	·820	·937	1·875
1	·187	·250	·312	·375	·437	·500	·625	·750	·875	1·000	2·000

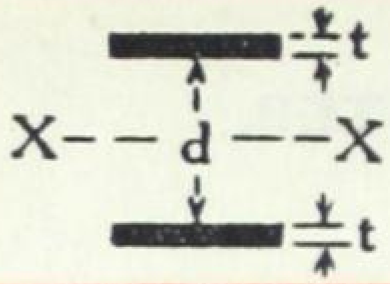
The latter portion of the table enables the requisite deduction to be made for bolt and rivet holes.
For Weights per Foot, see pages 252 and 253.

Tests, Extras.

Weights, Measures.

Math. tables.

Index, Code.



MOMENTS OF INERTIA OF TWO PLATES

PER INCH WIDTH, ABOUT THE XX AXIS.

For Plates to B.F. Beams, use table on pages 260, 261.

Inside Depth. d	Thickness (t) of Plates in Inches.									Inside Depth. d
	3/8	1/2	5/8	3/4	7/8	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	
Ins.	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.^{4}	Ins.
6	7·63	10·58	13·76	17·16	20·79	24·67	28·79	33·18	37·83	**6**
7	10·21	14·08	18·21	22·59	27·24	32·17	37·37	42·86	48·66	**7**
8	13·16	18·08	23·29	28·78	34·57	40·67	47·07	53·80	60·86	**8**
9	16·49	22·58	28·99	35·72	42·78	50·17	57·90	65·99	74·43	**9**
10	20·19	27·58	35·32	43·41	51·85	60·67	69·86	79·43	89·39	**10**
11	24·27	33·08	42·27	51·84	61·81	72·17	82·93	94·11	105·72	**11**
12	28·72	39·08	49·85	61·03	72·63	84·67	97·13	110·05	123·42	**12**
13	33·55	45·58	58·05	70·97	84·34	98·17	112·46	127·24	142·50	**13**
14	38·75	52·58	66·88	81·66	96·91	112·67	128·92	145·68	162·95	**14**
15	44·33	60·08	76·33	93·09	110·37	128·17	146·49	165·36	184·78	**15**
16	50·29	68·08	86·41	105·28	124·70	144·67	165·20	186·30	207·98	**16**
17	56·61	76·58	97·11	118·22	139·90	162·17	185·03	208·50	232·56	**17**
18	63·32	85·58	108·44	131·90	155·98	180·67	205·98	231·93	258·51	**18**
19	70·39	95·08	120·39	146·34	172·93	200·17	228·06	256·61	285·84	**19**
20	77·85	105·08	132·97	161·53	190·76	220·67	251·26	282·55	314·55	**20**
21	85·67	115·58	146·18	177·47	209·46	242·17	275·59	309·74	344·62	**21**
22	93·88	126·58	160·00	194·15	229·04	264·67	301·04	338·17	376·07	**22**
23	102·46	138·08	174·46	211·59	249·49	288·17	327·62	367·86	408·90	**23**
24	111·41	150·08	189·54	229·78	270·82	312·67	355·32	398·80	443·11	**24**
25	120·74	162·58	205·24	248·72	293·02	338·17	384·15	430·99	478·69	**25**
26	130·44	175·58	221·57	268·41	316·10	364·67	414·11	464·43	515·64	**26**
27	140·52	189·08	238·52	288·84	340·06	392·17	445·18	499·11	553·97	**27**
28	150·97	203·08	256·10	310·03	364·88	420·67	477·39	535·05	593·67	**28**
29	161·80	217·58	274·30	331·97	390·59	450·17	510·71	572·24	634·75	**29**
30	173·00	232·58	293·13	354·66	417·17	480·67	545·17	610·68	677·20	**30**
31	184·58	248·08	312·58	378·09	444·62	512·17	580·75	650·36	721·03	**31**
32	196·54	264·08	332·66	402·28	472·95	544·67	617·45	691·30	766·23	**32**
33	208·86	280·58	353·37	427·22	502·15	578·17	655·28	733·49	812·81	**33**
34	221·57	297·58	374·69	452·91	532·23	612·67	694·23	776·93	860·76	**34**
35	234·64	315·08	396·65	479·34	563·18	648·17	734·31	821·61	910·09	**35**
36	248·10	333·08	419·23	506·53	595·01	684·67	775·51	867·55	960·80	**36**
37	261·93	351·58	442·43	534·47	627·71	722·17	817·84	914·74	1012·9	**37**
38	276·13	370·58	466·26	563·16	661·29	760·67	861·29	963·18	1066·3	**38**
39	290·71	390·08	490·71	592·59	695·74	800·17	905·87	1012·9	1121·2	**39**
40	305·66	410·08	515·79	622·78	731·07	840·67	951·57	1063·8	1177·4	**40**
41	320·99	430·58	541·49	653·72	767·27	882·17	998·40	1116·0	1234·9	**41**
42	336·69	451·58	567·82	685·41	804·35	924·67	1046·4	1169·4	1293·9	**42**
48	438·79	588·08	738·91	891·28	1045·2	1200·7	1357·7	1516·3	1676·5	**48**
54	554·38	742·58	932·51	1124·2	1317·5	1512·7	1709·5	1908·2	2108·6	**54**
60	683·47	915·08	1148·6	1384·0	1621·4	1860·7	2101·9	2345·1	2590·2	**60**

MOMENTS OF INERTIA OF TWO PLATES—Continued.

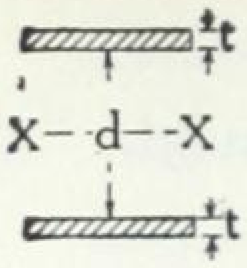
Inside Depth. d	Thickness (t) of Plates in Inches.									Inside Depth. d
	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3	
Ins.	Ins.⁴	Ins.⁴	Ins.⁴	Ins.⁴	Ins.⁴	Ins.⁴	Ins.⁴	Ins.⁴	Ins.⁴	Ins.
6	42·75	...	...	...	...	...	...	...	...	**6**
7	54·75	...	...	...	...	...	...	...	...	**7**
8	68·25	...	...	...	...	...	...	...	...	**8**
9	83·25	92·44	102·01	...	...	...	...	...	...	**9**
10	99·75	110·52	121·70	...	...	...	...	...	...	**10**
11	117·75	130·22	143·13	156·50	170·33	...	...	...	...	**11**
12	137·25	151·55	166·32	181·58	197·33	...	...	...	...	**12**
13	158·25	174·50	191·26	208·53	226·33	...	...	...	...	**13**
14	180·75	199·08	217·95	237·36	257·33	298·97	...	...	...	**14**
15	204·75	225·28	246·38	268·06	290·33	336·65	...	...	...	**15**
16	230·25	253·11	276·57	300·64	325·33	376·59	430·42	486·86	546·0	**16**
17	257·25	282·56	308·51	335·10	362·33	418·78	477·92	539·80	604·5	**17**
18	285·75	313·64	342·20	371·42	401·33	463·22	527·92	595·49	666·0	**18**
19	315·75	346·34	377·63	409·63	442·33	509·90	580·42	653·93	730·5	**19**
20	347·25	380·67	414·82	449·71	485·33	558·84	635·42	715·11	798·0	**20**
21	380·25	416·63	453·76	491·66	530·33	610·03	692·92	779·05	868·5	**21**
22	414·75	454·20	494·45	535·49	577·33	663·47	752·92	845·74	942·0	**22**
23	450·75	493·41	536·88	581·19	626·33	719·15	815·42	915·18	1018·5	**23**
24	488·25	534·23	581·07	628·77	677·33	777·09	880·42	987·36	1098·0	**24**
25	527·25	576·69	627·01	678·22	730·33	837·28	947·92	1062·3	1180·5	**25**
26	567·75	620·77	674·70	729·55	785·33	899·72	1017·9	1140·0	1266·0	**26**
27	609·75	666·47	724·14	782·75	842·33	964·41	1090·4	1220·4	1354·5	**27**
28	653·25	713·80	775·32	837·83	901·33	1031·3	1165·4	1303·6	1446·0	**28**
29	698·25	762·75	828·26	894·79	962·33	1100·5	1242·9	1389·6	1540·5	**29**
30	744·75	813·33	882·95	953·61	1025·3	1172·0	1322·9	1478·2	1638·0	**30**
31	792·75	865·53	939·39	1014·3	1090·3	1245·7	1405·4	1569·7	1738·5	**31**
32	842·25	919·36	997·57	1076·9	1157·3	1321·6	1490·4	1663·9	1842·0	**32**
33	893·25	974·81	1057·5	1141·3	1226·3	1399·8	1577·9	1760·8	1948·5	**33**
34	945·75	1031·9	1119·2	1207·7	1297·3	1480·2	1667·9	1860·5	2058·0	**34**
35	999·75	1090·6	1182·6	1275·9	1370·3	1562·9	1760·4	1962·9	2170·5	**35**
36	1055·3	1150·9	1247·8	1346·0	1445·3	1647·8	1855·4	2068·1	2286·0	**36**
37	1112·3	1212·9	1314·8	1417·9	1522·3	1735·0	1952·9	2176·1	2404·5	**37**
38	1170·8	1276·5	1383·4	1491·7	1601·3	1824·5	2052·9	2286·7	2526·0	**38**
39	1230·8	1341·7	1453·9	1567·4	1682·3	1916·2	2155·4	2400·2	2650·5	**39**
40	1292·3	1408·5	1526·1	1645·0	1765·3	2010·1	2260·4	2516·4	2778·0	**40**
41	1355·3	1476·9	1600·0	1724·5	1850·3	2106·3	2367·9	2635·3	2908·5	**41**
42	1419·8	1547·0	1675·7	1805·8	1937·3	2204·7	2477·9	2757·0	3042·0	**42**
48	1838·3	2001·6	2166·6	2333·1	2501·3	2842·6	3190·4	3544·9	3906·0	**48**
54	2310·8	2514·7	2720·4	2928·0	3137·3	3561·5	3992·9	4431·7	4878·0	**54**
60	2837·3	3086·3	3337·3	3590·3	3845·3	4361·3	4885·4	5417·6	5958·0	**60**

Tests, Extras.

Weights, Measures.

Math. tables.

Index, Code.



MOMENTS OF INERTIA OF FLANGE PLATES

FOR B.F. BEAMS AND OTHER METRIC SECTIONS.

DEPTH OF BEAM.			Moment of Inertia of Beam	I_x of hole 1″ dia. in each Flange.	MOMENTS OF INERTIA OF PLATES, PER INCH WIDTH.						
Nominal.	Exact.		I_x		$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{5}{8}$″	$\frac{3}{4}$″	$\frac{7}{8}$″	1″	$1\frac{1}{8}$″
Inches.	Inches.	Mm.	Ins.^{4}	Ins.^{4}	Inches.^{4}	Inches.^{4}	Inches.^{4}	Inches.^{4}	Inches.^{4}	Inches.^{4}	Inches.^{4}
5½	5·51	140	36·6	6·0	6·50	9·05	11·80	14·76	17·95	21·36	25·00
6	5·91	150	45·6	7·0	7·42	10·29	13·39	16·70	20·25	24·04	28·08
6¼	6·30	160	63·3	9·1	8·36	11·58	15·03	18·71	22·63	26·81	31·25
7	7·09	180	92·1	11·8	10·45	14·41	18·63	23·10	27·85	32·87	38·17
8	7·87	200	143	16·6	12·77	17·55	22·61	27·96	33·60	39·54	45·79
8½	8·66	220	193	20·4	15·32	21·00	26·99	33·28	39·90	46·83	54·11
9½	9·45	240	281	27·1	18·10	24·77	31·75	39·08	46·74	54·76	63·13
10	9·84	250	319	29·6	19·59	26·77	34·28	42·15	50·37	58·95	67·90
10¼	10·24	260	362	32·2	21·12	28·84	36·94	45·33	54·12	63·29	72·84
11	11·02	280	498	41·3	24·37	33·22	42·45	52·06	62·06	72·45	83·26
12	11·81	300	619	47·9	27·85	37·91	48·37	59·24	70·52	82·23	94·37
12½	12·60	320	775	59·7	31·57	42·91	54·68	66·88	79·58	92·62	106·2
13½	13·39	340	888	68·0	35·51	48·23	61·39	75·01	89·09	103·6	118·7
14	14·17	360	1084	82·8	39·69	53·85	68·47	83·58	99·18	115·3	131·9
15	14·96	380	1224	93·0	44·11	59·78	75·95	92·63	109·8	127·5	145·8
16	15·75	400	1457	111	48·75	66·02	83·81	102·1	121·0	140·4	160·4
17	16·73	425	1669	127	54·88	74·26	94·19	114·7	135·7	157·4	179·6
18	17·72	450	2023	152	61·38	82·99	105·2	128·0	151·3	175·3	199·9
19	18·70	475	2285	171	68·24	92·19	116·8	142·0	167·8	194·2	221·3
20	19·69	500	2719	203	75·46	101·9	128·9	156·7	185·0	214·1	243·8
22	21·65	550	3372	248	91·00	122·7	155·1	188·3	222·2	256·8	292·1
24	23·62	600	4344	315	108·0	145·5	183·8	222·8	262·7	303·3	344·7
26	25·59	650	5208	373	126·4	170·2	214·8	260·3	306·6	353·7	401·7
28	27·56	700	6494	461	146·3	196·8	248·3	300·6	353·8	408·0	463·0
30	29·53	750	7598	532	167·7	225·4	284·2	343·8	404·5	466·1	528·8
32	31·50	800	8802	609	190·5	256·0	322·5	390·0	458·6	528·2	598·8
34	33·46	850	10665	728	214·7	288·4	363·2	439·1	516·0	594·1	673·2
36	35·43	900	12158	821	240·4	322·8	406·3	491·0	576·9	663·8	752·0
38	37·40	950	13765	918	267·6	359·2	451·9	545·9	641·1	737·5	835·2
40	39·37	1000	15490	1021	296·2	397·4	499·9	603·7	708·7	815·0	922·6

(1) EXPLANATION. The table gives the I_x per inch of width of a pair of plates of the specified thickness (t).

The tabulated I_x for the beam (and for holes) is for a B.F. Beam of the *medium* weight (DIN series). For the moments of inertia of other weights of these sections, see table on page 16.

[Continued opposite.]

MOMENTS OF INERTIA OF FLANGE PLATES

FOR B.F. BEAMS AND OTHER METRIC SECTIONS—Continued.

MOMENTS OF INERTIA OF PLATES, PER INCH WIDTH.—Continued.											Nominal Depth.
1¼"	1⅜"	1½"	1⅝"	1¾"	1⅞"	2"	2⅛"	2¼"	2⅜"	2½"	d
Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.⁴	Inches.
28·89	33·02	...	...	...	...	...	...	...	...	...	5½
32·37	36·92	...	...	...	...	...	...	...	...	...	6
35·95	40·93	...	...	...	...	...	...	...	...	...	6½
43·77	49·66	55·86	...	...	...	...	...	...	...	...	7
52·36	59·24	66·47	...	...	...	...	...	...	...	...	8
61·72	69·68	78·00	...	...	...	...	...	...	...	...	8½
71·87	80·98	90·47	...	...	...	...	...	...	...	...	9½
77·23	86·95	97·06	...	...	...	...	...	...	...	...	10
82·78	93·12	103·9	115·0	126·6	...	...	...	...	...	...	10½
94·48	106·1	118·2	130·7	143·7	...	...	...	...	...	...	11
106·9	120·0	133·4	147·4	161·8	...	...	...	...	...	...	12
120·2	134·7	149·6	165·1	181·0	197·5	214·4	231·9	...	...	...	12½
134·2	150·2	166·8	184·8	201·3	219·4	238·1	257·2	...	...	...	13½
149·0	166·6	184·8	203·5	222·7	242·5	262·9	283·8	...	...	...	14
164·6	183·9	203·8	224·2	245·2	266·8	289·0	311·8	...	...	...	15
180·9	202·0	223·7	245·9	268·8	292·3	316·3	341·0	...	...	...	16
202·4	225·8	249·9	274·5	299·8	325·7	352·2	379·4	...	...	...	17
225·2	251·0	277·5	304·7	332·5	360·9	390·1	419·9	450·4	481·6	513·5	18
249.1	277·5	306·6	336·4	366·9	398·0	429·9	462·4	495·7	529·7	564·5	19
274·2	305·4	337·2	369·7	402·9	436·9	471·6	507·0	543·2	580·1	617·8	20
328·2	365·0	402·6	441·0	480·2	520·1	560·8	602·4	644·7	687·9	731·9	22
387·0	430·0	473·9	518·6	564·2	610·6	657·8	705·9	754·9	804·8	855·5	24
450·6	500·3	551·0	602·5	655·0	708·3	762·6	817·8	873·9	931·0	989·0	26
519·0	576·0	633·9	692·7	752·5	813·3	875·1	937·8	1001	1066	1132	28
592·4	657·0	722·6	789·2	856·9	925·6	995·3	1066	1138	1211	1285	30
670·5	743·3	817·1	892·0	968·0	1045	1123	1203	1283	1365	1447	32
753·5	834·9	917·5	1001	1086	1172	1259	1347	1437	1528	1619	34
841·3	931·9	1024	1116	1211	1306	1403	1500	1599	1700	1801	36
934·1	1034	1136	1238	1342	1447	1554	1662	1771	1881	1993	38
1032	1142	1253	1366	1480	1596	1713	1831	1951	2072	2194	40

(2) ALTERNATIVE TO PLATING. Unless the quantity required is trifling, there is seldom any point in plating B.F. Beams—since, by spacing the rolls, they can be produced in so many weights.

(3) FORMULA. $I = \left\{(d + 2t)^3 - d^3\right\} \div 12$

in which t = thickness of plates on each flange, d = depth of beam.

Tests, Extras.

Weights, Measures.

Math. tables.

Index, Code.

TESTS.

EXTRAS.

Tests, Extras.

Weights, Measures.

Math. tables.

Index, Code.

COMPARISON OF TESTS FOR STRUCTURAL STEEL

Below are given the main provisions governing the quality of structural steel, as prescribed by the British Standards Institution and the principal foreign authorities. The comparison is both interesting and instructive.

The abbreviations employed are: T = Tensile strength ; t = thickness of test piece.

For Cold Bend tests, the figures given below in terms of t are the diameter of the mandril round which the test piece must bend through an angle of 180° without sign of fracture.

Approximate equivalents in tons per square inch are given for the specified minimum tensile; for more exact equivalents, refer to the table on page 272.

The stated elongations are measured on a gauge length of 200 mm. or 8 inches.

1. British Standard Specifications.

B.S.S. 15—1936 ... Tensile 28–33 tons per square inch.
Elongation 20% ($t = \frac{3}{8}$″ and over). Cold Bend $3t$.
Open hearth (basic or acid) or Bessemer acid process.
Phosphorus and sulphur each ·06% max.[1]

B.S.S. 548—1934... Tensile 37–43 tons per square inch.
Elongation 18% ($t = \frac{3}{8}$″ and over). Cold Bend $3t$.[2]

2. German Industrial Standards (D.I.N.). Three grades are standardised :—

St. 37/12 ... Tensile 37–45 kilos. per sq. mm. (23½ tons min.).
Elongation 25% min. Cold Bend $\frac{1}{2}t$.

St. 42/12 ... Tensile 42/50 kilos. (26⅝ tons min.).
Elongation 24% min. Cold Bend $2t$.

St. 44/12 ... Tensile 44–52 kilos. per sq. mm. (28 tons min.).
Elongation 24% min. Cold Bend $3t$.

3. German State Railways. These also employ the following :—

St. 48 ... Tensile 48–58 kilos. (30½ tons min.). Yield point 29 kilos. (18½ tons min.). Elongation 18% min. Cold Bend $2t$.

St. 52 ... Tensile 52–62 kilos. (33 tons min.). Yield point 36 kilos. (23 tons min.). Elongation 20% min. Cold Bend $2t$.

N.B.—The last-named steel—a copper chromium alloy—has also been extensively employed in building construction.

4. French State Railways.

Rolling Stock : Tensile 42 kilos. min. (26⅝ tons). Yield point 24 kilos. min. (15¼ tons). Elongation 25% min. Cold Bending, flat without mandril. There is also a punching test.

Bridges : As above, but Cold Bending is round $1\frac{1}{2}t$.

N.B.—The Public Works Department requires test pieces to bend double flat, for bridge construction.

[1] Further details on page 269.
[2] Further details on page 270.

COMPARISON OF TESTS FOR STRUCTURAL STEEL.—Cont'd.

5. American Society for Testing Materials (A.S.T.M.). A7 (Bridges and Buildings).

In addition to the undermentioned mechanical tests, the Open-Hearth process is specified and the following chemical limits *with a tolerance of* 25% : Phosphorus ·04% (·06% for acid steel), Sulphur ·05% max. Tensile strength 55–65,000 lb. ($24\frac{1}{2}$ tons min.). Yield point 50% min. Elongation 1,500,000 ÷ T, min.* Cold Bend tests : $\frac{3}{4}''$ and under, $\frac{1}{2}\,t$. Over $\frac{3}{4}''$ to 1″, d = *t*. Over 1″, d ranges from $1\frac{1}{2}$ to 3 *t* according to thickness.

N.B.—The foregoing data are not applicable to Rivets, for which a softer steel is specified.

GENERAL NOTES.

The foregoing data shew how divergent are the prescriptions in different countries in regard to tensile strength, steel-making process and chemical analysis. Dealing with these three questions seriatim :—

(i) It will be observed that other countries prefer for general structural purposes a softer steel than the standardised British 28 to 33 tons tensile. But high tensile steels are also used, especially in Germany.

(ii) Both the British and American authorities vary the specified limits of phosphorus and sulphur according to the steel-making process.

(iii) The Continental authorities make no stipulations as to the process of manufacture ; nor any stipulations as to chemical analysis, relying wholly on mechanical tests.

These differences in national specifications are, in fact, due in the main, not so much to differences of technical opinion, as to economic and practical considerations and an element of "economic nationalism."

Tensile Strength. Towards the end of the 19th Century, the Bessemer process, which in its early days had produced very unsatisfactory results, was in England well-nigh abandoned in favour of the Siemens Open-Hearth Furnace, using the Acid Process. By this process, the grade of steel which could be produced most cheaply was that shewing a tensile strength of about 30 tons per square inch ; to produce a softer steel meant prolonged working in the furnace and greater expense. It was thus that the classic British 28/32 (now 28/33) tons tensile came into being. Now that the Acid Process has been almost entirely abandoned, this economic inducement no longer exists. Nevertheless, the 28/33 tons grade has remained the standard and has proved entirely satisfactory for all ordinary requirements : but for shipbuilding, steel exposed to heat, arc welding, etc., a softer, more ductile steel is usually preferred.*

The 28/33 grade has the advantage, other things being equal, that it can safely be stressed higher than the softer steels in vogue in other countries. As compared, for example, with the soft steel normally used on the Continent, British steel can, in theory at least, be stressed 15% higher than the Continental steel.†

[Continued on page 266.]

* For steel over $\frac{3}{4}''$ or under $\frac{5}{16}''$ thick, reduced percentages of elongation are allowed.

† Seeing, however, that the increase in tensile strength cannot be obtained without a corresponding sacrifice of ductility, which is also a most important element in determining the real factor of safety, the permissible increase of stress cannot really be put so high as 15%.

COMPARISON OF TESTS FOR STRUCTURAL STEEL.—Cont'd.

Process. The customary British and American stipulations in regard to process and chemical analysis are likewise traceable to a variety of considerations, not wholly technical.

Among British and American engineers, there is a very strong prejudice against the Bessemer, and more particularly the Bessemer Basic process. It is attributable to a variety of considerations—failures in the early days, notably that of the Embabeh Bridge in Egypt; a desire to exclude foreign steel, which was often of inferior quality; and, finally, because the steel maker can, undoubtedly, exercise greater control over the steel in the Open-Hearth Furnace.

Under modern conditions these considerations have lost most of their validity. The Bessemer Basic process, as employed by the leading Continental works, has been enormously improved, and the necessity of control during the steel-making process has been minimised by the use of ores of uniform composition and large mixers.

Chemical Analysis. As is well known, sulphur and phosphorus render steel brittle in the hot and cold states respectively. One common objection to the Bessemer Basic process is that it demands a higher allowance of phosphorus than the Open-Hearth process, for there is the risk of burning the metal if the blow is continued until the whole of the phosphorus is removed; some is inevitably added also from the slag when the "additions"—ferro-manganese etc.—are made.

In fact, however, the presence of phosphorus up to ·08%, in *mild* steel, seems to be practically negligible in its effects. Defective steel is most often caused by factors independent of its chemical composition and of the steel-making process, such as oxidisation, occluded gas, teeming of the ingots at too high or too low a temperature, insufficient cropping of the ingot. A defective product may also result from internal stresses caused by ill-designed rolls, too low a temperature in rolling, or too rapid cooling.

In short, the Continental practice of prescribing mechanical tests alone (tensile and cold-bending tests), leaving the manufacturer free to choose his own means of arriving at the desired results, seems to be the more scientific attitude.

The following pronouncement of the Chairman (Dr. W. H. Hatfield) of a Joint Committee of the Iron & Steel Institute and National Federation of Iron & Steel Manufacturers on the Heterogeneity of Steel Ingots is of interest in this connection :—

"The nature of the inside of the ingot determined the application of the steel to a given purpose ; and the nature of the inside of the steel was entirely independent of the process. The process used was determined by the cost of that process under local conditions." (Iron & Steel Institute, 4th Report on the Heterogeneity of Steel Ingots, 1932, page 222.)*

* A suggestion had been made that the thick-skinned Continental ingot with segregation confined to the interior is, for some purposes at least, superior to the ordinary Open-Hearth steel ingot. The statement quoted above was made in response to requests that it should be stated that similar ingots can be produced in Open-Hearth steel. From the engineer's standpoint, it is clearly preferable that segregation should be confined to the interior of the ingot, since the skin of the ingot corresponds to the outer fibres of the finished section, where normally the greatest stresses occur.

TESTS FOR BROAD FLANGE BEAMS.

PROCESS.

The steel-making process employed at Differdange is the Bessemer Basic or Thomas process. Their beams have been extensively employed in every type of structure during the last 35 years : not only in buildings of all kinds, but in crane runways, coaling staiths, wharves and main-line railway bridges. Many authorities who ordinarily reject Bessemer Basic steel for bridge construction—*e.g.*, the various Australian State Railways, the Chinese Government Railways, and the leading Argentine railways—have made an exception in favour of the Differdange product, recognising that it is fully equal to that of the best Open-Hearth steelmakers. Its unimpeachable quality is due to the facts that the Differdange Works make their steel from local ores of uniform composition, use large mixers, and crop the ingot drastically in its passage both from the blooming to the intermediate mill and from this to the finishing mill ; also to the nature of the rolling process, *i.e.*, the Grey Process (see pages 11–13).

AVAILABLE QUALITIES.

[N.B.—The undermentioned extras, some only approximate, were those ruling in Dec., 1947 ; they are liable to alteration without notice.]

(i) 'Standard' quality, tensile strength 26/30 tons per square inch, with 22% minimum elongation in 8 inches (on metal ⅜″ and thicker†)...no extra.

This grade is recommended as the best for most purposes.‡

(ii) British Standard quality, tensile strength 28/33 tons per square inch, with 20% minimum elongation in 8 inches (on metal ⅜″ and thicker†)...6/– per ton extra, in addition to the undermentioned extra for test certificate or inspection, when required.

(iii) Soft steel, having a tensile strength of 23½ to 28 tons per square inch, with 25% minimum elongation in 8 inches (on metal ⅜″ and thicker†)...no extra.

(iv) To the German St. 48 specification, viz. :—Tensile strength 48–58 kilos (30½ tons min.), yield point 29 kilos (18½ tons) min., elongation 18% minimum in 8 inches...about 50/– per ton extra.

(v) To the German St. 52 specification (Chrome-copper steel), viz. :—Tensile strength 52–62 kilos (33 tons min.), yield point 36 kilos (23 tons min.), elongation 20% minimum in 8 inches...about £3 per ton extra.

(vi) To the mechanical tests of the A.S.T.M. specifications A7 or A9 (tensile 55,000–65,000 pounds)...no extra.

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† British Standard Specification 15 reduces the minimum elongation to 16% for a thickness of under ⅜″ down to ¼″, and eliminates tensile tests on material under ¼″.

‡ Compare with the general notes on tensile strength above. The same grade (26/30 tons tensile) is employed by the Admiralty for mild steel, and by the Board of Trade and Lloyds Registry for boiler plates. As the ***modulus of elasticity*** is practically constant for all grades of mild steel, the ***deflection*** under a given load is the same whether the tensile strength be 26 or 33 tons per square inch. But an equally reliable product can be given to British Standard tests (28/33 tons tensile), if preferred.

TESTS FOR BROAD FLANGE BEAMS.—Continued.

EXTRA FOR TESTS AND INSPECTION.

For any of the above-mentioned grades there is a further extra when sold subject to test certificate or inspection, viz., 4s. 0d. or 10s. 0d. per ton respectively.

COPPER CONTENT.

Any of the foregoing grades can be supplied with a Copper content, if desired (·25 to ·35% unless otherwise specified) at an extra of about 15s. 0d. per ton.

LONDON BUILDINGS.

The London County Council's 1932 Code of Practice, by stipulating that steel be made by the Open-Hearth process, temporarily stopped the use of Broad Flange Beams in London buildings. The Code is now obsolete, and permission can be obtained for the use of Broad Flange Beams (in Bessemer Basic steel) by application under §9 of the London Building Act (Amendment Act) 1935; *i.e.*, by a procedure similar to that necessary for welded steelwork and other types of construction not covered by the Council's Bye-Laws. [1]

ROLLING MARGINS.

The rolling margin required on Broad Flange Beams is 4% under and over theoretical weights; and appropriate tolerances for wear and tear of rolls, etc., in profile and dimensions.

With the DIR (maximum) weights—and sections intermediate between the DIN and DIR weights—the rolling margin required is 6% under and over, with tolerances of 1/16″ and 1/8″ in the thickness of webs and flanges respectively.

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[1] Every application must be accompanied by adequate particulars and approval will be subject to conditions prescribed by the Council in each case.

ABSTRACTS FROM

BRITISH STANDARD SPECIFICATION No. 15 (Feb., 1936).

Structural Steel for Bridges, etc., and General Building Construction.

Process. The only steel-making processes at present recognised are the Open-Hearth Process (Acid or Basic) and the Bessemer Acid Process ; with ·06% max. of Sulphur and of Phosphorus.

[Until 1930, a "B" grade—Bessemer Acid or Basic—with ·08% Phosphorus was recognised. Now that British makers (of structural steel) all employ the Open-Hearth Process there is, from the makers' standpoint, no need to recognise any other process.]

Tensile Tests (§ 5).

(*a*) 28 to 33 tons per square inch with 20% minimum elongation in 8 inches; 16% for steel from $\frac{3}{8}''$ down to $\frac{1}{4}''$ (Test piece A). This applies to Plates, Sections, and Flat Bars.

(*b*) Round and Square Bars (other than rivet bars) the same tensile strength, but with 20% minimum elongation in 8 diameters (Test piece B) ; if over 1″ diameter, 24% in 4 diameters (Test piece B.1, formerly Test piece F.)

(*c*) Rivet steel : 25 to 30 tons tensile per square inch with 26% minimum elongation in 8 diameters or 30% in 4 diameters (Test pieces B and B.1, formerly Test piece F, respectively).

N.B.—For Round and Square Bars under $\frac{3}{8}''$ (unless for concrete reinforcement), only bend tests are required.

Number of Tests, etc.

(*a*) Usually one tensile test per size or cast and another test for casts of over 25 tons, or in case of rivet steel for every 10 tons or part thereof in excess of 10 tons (§ 6).

(*b*) For mode of preparing and selecting Test Pieces, see §§ 3 and 4. For dimensions, see B.S.S. 18-1938 or page 271 hereof.

(*c*) See also § 12 (one chemical analysis per cast if required) ; § 15 (additional Tests) ; § 13 (Tests to be made at mills) ; § 21 (Test Certificates and Stock Material) ; §§ 19 and 20 (Cast Numbers, Branding and Mill Sheets).

Bend Tests.

(*a*) To bend cold till sides parallel round a radius equal to $1\frac{1}{2}$ times the thickness, but for round bars 1″ diam. and less, the radius shall not exceed the diameter (§ 9). Test piece not less than $1\frac{1}{2}''$ wide or, if small, taken from section as rolled (§ 7).

(*b*) One cold bend test for each plate, section or bar as rolled. Bend tests will not be made on Rivet Bars (§ 10).

Rivets.

(*a*) Tensile tests, as above.
(*b*) Shanks of finished rivets to bend double cold without fracture.
(*c*) Heads of finished rivets to flatten hot without cracking till diameter of head is $2\frac{1}{2}$ times that of shank (§ 11).

Rolling Margin (§ 17). $2\frac{1}{2}$% under and over for Sections and Flat Bars ; for Plates over $\frac{1}{4}''$; and for Rounds, Squares, and Rivet Bars over $\frac{3}{8}''$.

For Plates of $\frac{1}{4}''$ and less, 5% under and over. For Rounds, Squares, and Rivet Bars $\frac{3}{8}''$ and less, 4% under and over.

When a minimum weight is specified, the foregoing rolling margins are doubled, and taken wholly over ; for a maximum weight, the rolling margin is doubled and taken wholly under.

Cutting Margin (§ 17). 1″ under and over (or 2″ if over only). "Exact lengths" means cold sawn or machined within $\frac{1}{8}''$ "over and under."

Variation in Depth of Beams and Channels. Up to 12″ deep, $\frac{1}{8}''$ over or $\frac{1}{32}''$ under ; above 12″ to 16″, $\frac{5}{32}''$ over or $\frac{1}{16}''$ under ; above 16″, $\frac{3}{16}''$ over or $\frac{1}{16}''$ under.

ABSTRACTS FROM

BRITISH STANDARD SPECIFICATION No. 548 (May, 1934).

High Tensile Structural Steel for Bridges and General Building Construction.

Process. Open Hearth (Acid or Basic), or Bessemer Acid, with the following maxima :—

Carbon 0·3% (for Rivet Bars ·25%), Sulphur 0·05%, Phosphorus 0·05% ; and subject to agreement between maker and client, 0·06% Copper.

Tensile Strength (§ 5).

Plates, Sections, and Flat Bars $\frac{3}{16}''$ thick and over, and Rounds and Squares (concrete reinforcing and rivet bars excepted), $\frac{3}{8}''$ thick and over, the tensile breaking strength to be 37 to 43 tons per square inch. For Plates, etc., *under* $\frac{3}{16}''$ thick, and for Rounds and Squares (reinforcing bars excepted), only bend tests are required.

Yield point.

For Plates, Sections and Flat Bars—23 tons per square inch for thicknesses of $\frac{1}{4}''$ to $1\frac{1}{4}''$ inclusive, 22 tons for over $1\frac{1}{4}''$ thick up to $1\frac{3}{4}''$, 21 tons for over $1\frac{3}{4}''$ up to $2\frac{1}{4}''$, 20 tons for over $2\frac{1}{4}''$ up to $2\frac{3}{4}''$, 19 tons for over $2\frac{3}{4}''$. For Round and Square Bars—23 tons per square inch up to 1″ inclusive, 22 tons for over 1″ up to $1\frac{1}{2}''$, 21 tons for over $1\frac{1}{2}''$ to 2″, 20 tons for over 2″ up to $2\frac{1}{2}''$, 19 tons for over $2\frac{1}{2}''$.

The rate of loading when approaching the yield point not to exceed $\frac{1}{2}$ ton per square inch per second ; in case of dispute the divider method to be used.

Elongation.

On test pieces A or B, the minimum elongation to be 18% on steel $\frac{3}{8}''$ thick and thicker, 14% on thicknesses under $\frac{3}{8}''$. On test piece B1, formerly F, 22% minimum.

Rivet bars. These to have a tensile strength of 30 to 35 tons per square inch with 22% minimum elongation on test piece B or 27% on test piece B1 (formerly F).

Other Clauses.

The clauses relating to Number of tests, Bend tests, Rivet bend tests, Rolling and Cutting margins are similar to B.S.S. 15–1934, brief extracts from which will be found on page 269.

OTHER BRITISH STANDARD SPECIFICATIONS.

2–1944 Tram Rails and Fishplates.
4–1932 Channels and Beams.
4a–1934 Angles and Tees, Properties.
6–1924 Bulb Angles and Bulb Plates.
8–1939 Steel tubular traction poles.
9–1935 Bullhead Rails.
11–1936 Flat Bottom Rails.
13–1942 Shipbuilding Steel, Structural.
15–1936 Structural Steel for Bridges and General Building.
18–1938 Tensile Testing of Metals.
24–Var. Materials for Rolling Stock (6 parts).
47–1928 Fishplates for Rails.
84–1940 Whitworth Screw Threads.
105–1919 Steel Bridge Rails.
153–Var. Girder bridges (5 parts).
325–1928 Black Bolts and Nuts, Sizes.
449–1937 Use of Structural Steel.
466–1932 Overhead Electric Cranes.
476–1932 Fire Resisting Materials.
538–1940 Electric Arc Welding.
548–1934 High Tensile Structural Steel.
639–1935 Arc Welding, Covered Electrodes.

TENSILE TEST PIECES.

BRITISH STANDARD FORMS AND DIMENSIONS.

B.S.S. 18—1938 standardizes various test pieces for "Tensile Testing of Metals."

The A types are chiefly for Plates, Flats, and Sections; B for unmachined Rods and Bars.

TYPE A. This is a flat test piece with enlarged ends; overall length about 18″, parallel length 9″ minimum, gauge length 8″; width 2″ maximum for thicknesses of $\frac{1}{4}$″ to $\frac{7}{8}$″, $1\frac{1}{2}$″ maximum for material over $\frac{7}{8}$″.

For thicknesses up to $\frac{1}{4}$″, gauge lengths of either 2″ or 4″, and widths of $\frac{1}{2}$″ and 1″ respectively are substituted.

TYPE A1. This is an optional alternative for "special sheet and strip materials": overall length about 15″, gauge length 8″, parallel length 9″, width $\frac{3}{4}$″.

TYPE B. This is chiefly for rods and bars up to 1″ diameter: gauge length 8 diameters, distance between grips 9 diameters minimum. (With hexagons and squares, for "diameter" substitute distance between the flats.)

TYPE B1. For rods and bars over 1″ diameter, the gauge length is 4 diameters, and the distance between grips is $4\frac{1}{2}$ diameters minimum.

N.B.—It must be borne in mind that tensile tests on material as rolled involve expensive machining and a substantial amount of waste: in the case of a heavy section, $1\frac{1}{2}$ feet of waste. For this reason, test certificates are nowadays usually founded on tests made on a specimen taken from the ladle, and an extra is charged for testing the material as rolled. Sections are tested in the direction of rolling; plates both lengthwise and crosswise, or crosswise only. Except for high-class boiler plates, a reduced elongation is usually allowed in crosswise tests.

EQUIVALENT TENSILE STRENGTHS.

Intermediate equivalents can be calculated by addition.

Per Square Inch		Kilos per Sq. Mm.	Per Square Inch.		Kilos per Sq. Mm.	Kilos per Sq. Mm.	Per Square Inch.	
Tons.	Lb.		Lb.	Tons.			Tons.	Lb.
½	1,120	0·787	1,000	0·446	0·703	½	0·317	711
1	2,240	1·575	2,000	0·893	1·406	1	0·635	1,422
2	4,480	3·150	3,000	1·339	2·109	2	1·270	2,845
3	6,720	4·725	4,000	1·786	2·812	3	1·905	4,267
4	8,960	6·300	5,000	2·232	3·515	4	2·540	5,689
5	11,200	7·874	6,000	2·679	4·218	5	3·175	7,112
6	13,440	9·449	7,000	3·125	4·921	6	3·810	8,534
7	15,680	11·024	8,000	3·571	5·625	7	4·445	9,956
8	17,920	12·599	9,000	4·018	6·328	8	5·080	11,379
9	20,160	14·174	10,000	4·464	7·031	9	5·715	12,801
...	...	...	...	...	...	...	...	...
20	44,800	31·50	20,000	8·93	14·06	20	12·70	28,446
21	47,040	33·07	30,000	13·39	21·09	30	19·05	42,670
22	49,280	34·65	...	...	...	...	...	...
23	51,520	36·22	...	...	...	32	20·32	45,515
24	53,760	37·80	40,000	17·86	28·12	34	21·59	48,359
25	56,000	39·37	45,000	20·09	31·64	35	22·22	49,782
26	58,240	40·95	50,000	22·32	35·15	36	22·86	51,204
27	60,480	42·52	55,000	24·55	38·67	38	24·13	54,049
28	62,720	44·10	60,000	26·79	42·18	40	25·40	56,893
29	64,960	45·67	65,000	29·02	45·70	42	26·67	59,738
30	67,200	47·25	70,000	31·25	49·21	44	27·94	62,583
31	69,440	48·82	75,000	33·48	52·73	45	28·57	64,005
32	71,680	50·40	80,000	35·71	56·25	46	29·21	65,427
33	73,920	51·97	85,000	37·95	59·76	48	30·48	68,272
34	76,160	53·55	90,000	40·18	63·28	50	31·75	71,117
35	78,400	55·12	95,000	42·41	66·79	52	33·02	73,961
36	80,640	56·70	100,000	44·64	70·31	55	34·92	78,228
37	82,880	58·27	105,000	46·88	73·82	58	36·83	82,495
38	85,120	59·85	110,000	49·11	77·34	60	38·10	85,340
39	87,360	61·42	115,000	51·34	80·85	70	44·45	99,563
40	89,600	63·00	120,000	53·57	84·37	75	47·62	106,675
45	100,800	70·87	125,000	55·80	87·88	80	50·80	113,786
50	112,000	78·74	130,000	58·04	91·40	85	53·97	120,898
55	123,200	86·62	135,000	60·27	94·91	90	57·15	128,010
60	134,400	94·49	140,000	62·50	98·43	100	63·50	142,233

STRUCTURAL STEELWORK.

NOTES ON SPECIFYING.

The particulars which should accompany an enquiry or contract for finished steelwork may be classed under the following heads :—

(i) Schedule of Material or Bill of Quantities.

(ii) Drawings.

(iii) Conditions as to quality of materials, workmanship, etc.

(iv) Contract conditions special to the contract in question, such as :—Time for Delivery (and Erection), Penalty for late Delivery, Place of and Facilities for Delivery, Terms of Payment, Date for receipt of Tender, Inspection, etc.

BILL OF QUANTITIES.

(i) The most useful form is a list of the various members, each item being so described as to shew the whole of the workmanship required thereon. A common form, giving only the aggregate quantities of cleats, holes and rivets, is difficult to price and almost useless for estimating purposes.

(ii) In any case, it is rarely possible to give a reliable estimate on a Bill of Quantities alone ; drawings also should be supplied.

DRAWINGS.

When competitive tenders are required, drawings should be fully detailed ; to leave either scantlings or connections to the discretion of competing firms, offers an obvious inducement to cut down weight and cost to the danger point.

TIME FOR DELIVERY.

Whenever possible the buyer should indicate the time within which delivery is required, as this greatly affects the cost of materials. Thus, in the case of a very urgent order, the specification should call for delivery from stock materials.

DATE FOR RECEIPT OF TENDER.

For the steelwork of an average building, a week to a fortnight should be allowed for receipt of tenders. If time be an important consideration, it is the more necessary that contractors should have the opportunity of making special enquiries from rolling mills before framing their estimates.

SPECIFICATION.

The following conditions relating to quality of work and materials, tests, inspection, etc., accord with first-class practice. They are only intended to serve as a draft, some conditions being omitted and others modified to suit the special circumstances of the case.

STRUCTURAL STEELWORK.

DRAFT SPECIFICATION.

1. QUALITY OF STEEL.

If the steel is intended to be of British manufacture, the usual clause will be, " Where not otherwise specified, all steel to conform to British Standard Specification No. 15 (19...)."

For Broad Flange Beams, specify that they are to be manufactured by the Grey Process. To this, either add " to the mechanical tests of British Standard Specification 15," or specify the required grade (see page 267). It should also be expressly specified that Bessemer Basic steel may be supplied if of Differdange make.

2. WROUGHT IRON.

Wrought Iron to comply with British Standard Specification for Wrought Iron No. 51; Grade C for plates and bars, Grade B for rivets.

3. STEEL CASTINGS.

All steel castings must be thoroughly annealed and after annealing shall shew a tensile strength of 26 to 35 tons per square inch with a minimum elongation of 15% in 2″. Test pieces 1″ square, after being annealed with the casting, to bend cold without fracture through an angle 90° round a bar 1″ in diameter.

N.B.—For steel castings for marine purposes, see British Standard Specification No. 30, 1907.

4. CAST IRON.

Cast iron for bearing plates and other parts liable to strain to be of a quality such that a bar of iron cast from the same melt 3′ 6″ long, 2″ deep and 1″ wide when supported on bearings 3′ 0″ apart shall carry at the centre without breaking a weight of 28* cwts., and shall shew a minimum deflection of $\frac{1}{3}$″.

5. MALLEABLE CASTINGS.

Malleable castings to be of an approved mixture of iron shewing a tensile strength of not less than 15 tons per square inch. Samples from each cast to be furnished for tensile and bending tests.

6. ROLLED MATERIAL.

Must be free from seams, flaws, cracks, laminations and injurious defects of any kind.

Sections must be rolled as accurately as practicable to the specified weights and dimensions.

When the specified dimensions are those of a British Standard section, the remaining dimensions shall be those of the British Standard section thus indicated†. The dimensions of Broad Flange Beams to be as published by R. A. Skelton & Co. Steel & Engineering, Ltd., London.

7. TESTING AND INSPECTION.

[The specification will state whether material will be inspected by the engineer's representative or whether the manufacturer's test certificate will be accepted instead.

Material must be tested at the rolling mills.

Material supplied from stock cannot be tested nor, as a rule, can the cast be identified so as to enable a test certificate to be furnished. It is necessary, however, to allow trifling quantities of bolts and rivets, or materials for making them, to be taken from stock. The same remark applies to unimportant packings, fishplates, gusset plates and brackets.]

* For Cast Iron Gutters and the like, a breaking load of 25 cwts. is sufficient.

† This is to ensure that a joist specified as 20″ × 7½″ × 89 lb., for example, shall have the standard web and flange thicknesses, flange taper, etc.

8. ROLLING MARGIN.

For British Standard sections, see page 269.

N.B.—For Broad Flange Beams, Grey Process, the rolling margins required are 4% under and over theoretical weights (6% for the maximum weights) and appropriate tolerances in profile and dimensions; on aggregate weights a rolling margin of 2½% can be specified, excepting the " Dir " weights, however.

9. PLANING, MACHINING, ETC.

All ends of Beams used as stanchions are to be machined true and square in a fraizing or ending machine. All abutting surfaces are to be finished smooth and square, and if necessary, machined for this purpose after the end fittings have been riveted on.

Flange Plates, if made from sheared plates, must have had at least 1/8″ removed on each sheared edge by planing.

10. STRAIGHTENING.

Cold straightening of sections must be by pressure and not by hammering.

11. HOLES FOR BOLTS AND RIVETS.

(i) Ordinary round holes are to be of a diameter 1/16″ larger than the specified diameter of bolt or rivet.

(ii) Where not otherwise stated, holes must be drilled, or else punched 1/8″ small and afterwards drilled or reamed (but not drifted) to the required size. All burrs due to punching or drilling must be removed.*

(iii) All holes for site connections must be accurately centred so as to render reaming or drifting during erection unnecessary.

(iv) Multiple members, such as flange plates, to be drilled as far as practicable in one operation.

12. RIVETS.

N.B.—If the steel contractor has not to erect, state whether site connections will be riveted or bolted.

(i) Unless otherwise stated, rivets to be of soft steel, of the quality and to the tests prescribed for rivets in British Standard Specification No. 15 (page 269 hereof).

(ii) Ordinary rivets to have cup heads formed from a length of shank equal to not less than 1½ diameters. Rivets on bearing surfaces to be flush countersunk.

(iii) All rivets are to be machine-driven as far as practicable and must completely fill the holes when closed. If loose or if the heads are badly formed, cracked, or eccentric to the shank, or do not bear truly on the plate or bar, such rivets shall be cut out and replaced.

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* It is impossible to lay down general rules as to the cases in which holes may be punched the full diameter. Punching damages the neighbouring metal, but this is not always objectionable. Generally speaking, holes in fishplates and in metal under 1/2″ thick might be punched if any economy is to be gained. Really accurate centring of punched holes can only be obtained by the use of nipple punches. B.S.S. No. 153 permits holes up to 3/4″ diameter to be punched and reamed in plates and sections, and holes in floor plates, packings, tie plates and lacing bars up to 1/2″ thick to be punched full size, unless otherwise specified.

Weights, Measures
Math. tables.
Index, Code.

(iv) All surfaces to be riveted must be in close contact throughout.

(v) For "Spares," see § 21, below.

13. BOLTS.

N.B.—If the steel contractor has not to erect, state whether site connections will be riveted or bolted.

(i) Ordinary bolts and nuts to be of mild steel to British Standard Specification No. 15.

(ii) Unless otherwise indicated, bolt heads and nuts to be hexagonal and to Whitworth standard (bolts and nuts for timber are usually square).

(iii) Threads to be cut in oil and the fit of the nuts must be such that they can just (but only just) be screwed on with the fingers. Bolt heads must in no case be welded to the shanks.

(iv) Bolts must be long enough, allowing for washers, if any, to project (say $\frac{1}{4}''$) beyond the nut when tightened, and the screwed portion must be long enough to permit of subsequent tightening.

Timber bolts to be screwed at least three diameters and, when bearing on timber, to be provided with square washers $\frac{1}{4}''$ thick, of a size equal to three bolt diameters.

(v) Turned bolts to be of a driving fit in the holes they occupy and to have the screwed portion $\frac{1}{16}''$ less in diameter than the shank. The shanks of turned bolts must be parallel, a driving fit, and of a length sufficient to ensure contact through the entire thickness of the plates. Accordingly, washers, truly flat, must be provided under the nuts to ensure that they can be screwed home.

(vi) Where nuts or bolt heads bear on the tapered flanges of Joists or Channels, bevel washers to be provided of corresponding taper. (Broad Flange Beams, Grey Process, have parallel flanges.)

(vii) For "Spares," see § 21, below.

14. GALVANISED IRON AND STEEL.

(i) All galvanising is to increase the weight of the article by not less than 1 oz. per square foot of area treated. In the case of a corrugated sheet, since both sides are treated, this means 2 oz. per square foot reckoned on the dimensions of the sheet before being corrugated.

(ii) The sheets to be annealed, pickled, scaled and trimmed to the required size before galvanising.

(iii) After being galvanised, sheets must withstand bending double in either direction.

(iv) Fastenings of galvanised work are also to be galvanised; rivets to be of extra soft iron.

(v) Corrugated sheets to be laid with an end lap of not less than 6", zigzag riveted with one $\frac{1}{4}''$ diameter rivet to each corrugation and with a side lap of one corrugation riveted with $\frac{1}{4}''$ diameter rivets spaced not more than 8" apart centre to centre. (Sometimes two corrugations side lap is specified, but it seems unnecessary.)

(vi) The sheets are to be fastened to the framing by $\frac{5}{16}''$ diameter hook bolts and screws, spaced not more than half the width of the sheet apart.

(vii) Unless otherwise specified, all sheets are to be punched along one side and end.

(viii) For Packing, see § 20, below.

15. TIMBER.

Timber shall be fully seasoned and the best of its kind, sawn true, full size, free from wind, shakes, large or loose knots, decayed or sap wood, worm holes or other defects impairing its strength or durability. (State whether the timber is to be planed and, if so, whether on all sides.)

16. GLASS.

Glass is to be of the best quality of its kind and cut to size ready for fixing. When iron or steel glazing bars or frames are used and putty is employed for bedding the glass, holes are to be punched in the web of the bars at frequent intervals for the insertion of oak pegs or split pins for securing the panes of glass in place. (For roofing, ¼″ thickness is suitable.)

Unless otherwise specified, both putty and pegs are to be included in and form part of the contract.

For Packing, see § 20, below; for "Spares," § 21.

17. TIE BARS.

A reasonable percentage selected by the inspector from the bulk to be tested to destruction, when they must fracture in the body of the tie rod, the eye-end remaining sound.

18. PAINTING, ETC.

(i) Except as otherwise specified below, the whole of the finished iron and steelwork to be cleaned from scale, rust or dirt, and painted while thoroughly dry with one coat of boiled linseed oil applied hot or of good red oxide oil paint, before despatch from works.
N.B.—For shipment abroad, oiling is better than painting.

(ii) Surfaces riveted in contact and all inaccessible parts to be painted one coat before riveting.

(iii) Bolts, nuts, tubes and rivets to be dipped into hot boiled linseed oil before shipment.

(iv) Machined ends and turned bolts are not to be painted, but to be coated with tallow and white lead, or varnished.

(v) Steelwork which will be entirely embedded in concrete is not to be painted. After erection, such work to have scale and dirt removed and then to be coated twice with cement wash of the consistency of cream, the second coat being applied immediately prior to casing with concrete or building in.

(vi) Galvanised metal will not be painted before shipment.

(vii) Material to be inspected before despatch must not be painted till it has been inspected and passed.

19. MARKING.

In addition to any necessary shipping marks, all members are to bear suitable erection marks in accordance with key plans to be furnished by the steel contractor on shipment.

N.B.—When, as for South America, elaborate marking is required for Customs purposes, such should be expressly specified in the enquiry, as it adds to the cost.

20. PACKING. (The following apply only to export orders.)

(i) Small parts to be securely packed for shipment in cases of convenient weight and size for handling.

(ii) Bars under ¾″ diameter to be carefully bundled.

Weights, Measures
Math. tables.
Index, Code.

(iii) Galvanised corrugated sheets are to be bundled and packed in 5 cwt. strong crates and the edges of each bundle are to be so bound with felt as to prevent moisture getting between the sheets.

(iv) Glass to be packed in strong double cases with sufficient hay or straw to prevent damage in transit.

(v) The joints of cases to be covered with canvas.

21. SPARE PARTS.

(i) The contractor to supply all necessary loose bolts and rivets for field connections, together with 5% of spare bolts and 10% of spare rivets of each size and length.

N.B.—If the quantities are very large, the proportion of spares may be reduced to 5% for both bolts and rivets. If service bolts are to be supplied for the use of riveters on the site, this must be mentioned.

(ii) Spare panes of glass to be supplied to the extent of 10% of each size and shape.

22. SMITHED WORK.

All joggles and knees shall be formed by pressure and (where practicable) without cutting or welding, in such a manner as not to impair the strength of the metal.

23. ACCURACY.

In repetition work, the standard of accuracy must be such that similar parts are, in fact, interchangeable.

LONDON COUNTY COUNCIL BYE-LAWS, 1937

and

BRITISH STANDARD SPECIFICATION 449—1937

The following pages give a summary of the main provisions of British Standard Specification 449–1937, with references in brackets to the corresponding sections in the L.C.C. Bye-laws (1937). The original specifications must be referred to for the official text, but this summary will be found useful as a précis and index.

So far as the steelwork designer is concerned, the two specifications are very similar in substance; but by section 9 of the 1935 Amendment Act the Council has powers of modification and waiver. This very important provision enables the Council to depart from British Standard Specifications where such departure is necessary to enable the use of new methods of construction.

For overseas work it must not be forgotten that these specifications only purport to lay down minimum requirements for buildings, of normal type and in Great Britain. In other countries it may be necessary to provide for greater wind load, and a higher factor of safety in order to allow for lack of skilled labour in erection, etc.

Again, where foreign materials are to be used, or their use is not to be excluded, it must be remembered that the British Standard Specifications represent British manufacturing practice, and may have to be modified accordingly.

WELDING. B.S.S.449–1937 states that welding may be used subject to municipal regulations and bye-laws and to the requirements of B.S.S. 538 for Metal Arc Welding and 693 for Oxy-acetylene welding.

The London County Council has published a statement (December, 1937) indicating the conditions (maximum stresses, methods of calculation, etc.) which should be observed when applying for permission to use welded steelwork. The principal technical conditions will be found in the chapter on Welding (pages 234–241).

BRITISH STANDARD SPECIFICATION 449—1937
and
LONDON COUNTY COUNCIL BYE-LAWS, 1937.

PARTS I TO III. GENERAL.

1 **DEFINITIONS** (L.C.C. § 1).

Usual: *e.g.*, Effective column length is "the length upon which the ratio of column length to least radius of gyration is calculated."

2. **QUALITY OF STEEL** (L.C.C. §§ 15 and 63).

This to comply with B.S.S. 15–1936 (28–33 tons tensile) or B.S.S. 548–1934 (37–43 tons tensile). In testing the latter grade, the rate of application of the load, when approaching the yield point, must not exceed ½ ton per sq. inch per second.

5, 6. **PANEL WALLS.** (L.C.C. § 54).

Height not to exceed 25 feet; overhang not to exceed one-third of the thickness.

PART IV. LOADING.

7. **PARTITIONS** (L.C.C. § 4b).

Where intended but not shown in drawings, these are to be taken as equivalent to a (uniformly distributed) floor load of 20 lb. per foot.

8a. **FLOOR LOADS** (L.C.C. §§ 4 and 5).

Column A below gives the minimum load, in pounds per square foot of floor area, to be assumed in calculating the loads on beams, columns, piers, walls, and foundations: the figures in brackets (column A) are for slabs and other flooring materials.

The loads in column B take the place of former provisions for concentrated loads: floor beams and slabs must now be capable of supporting alternatively the superimposed loads shown in column B; these are for floor girders and slabs respectively (the latter in brackets). The specified loads are to be taken as uniformly distributed. In the case of slabs supported on all four sides ("spanning in two directions at right angles") the *shorter* span may be taken as the effective span. The slab loads in column B (in brackets) are *per foot of width.*

The B loads need not be considered in computing loads on columns and foundations.

Where floor beams are entirely embedded in concrete, and the spacing does not exceed 3 feet, centre to centre, the B load may be regarded as divided equally between a *pair* of beams.

		A Lb.	B Tons.
(i)	Domestic, hotel bedrooms, hospital rooms and wards	40 (50)	1 (1/4)
(ii)	Offices: floors above entrance floor	50 (80)	2 (3/8)
(iii)	Offices: entrance and below entrance floors; also retail shops and garages (cars up to 2 tons)	80 (80)	,,
(iv)	Churches, schools, reading rooms, and art galleries	70 (80)	,,
(v)	Assembly, drill and dance halls, gymnasia, light workshops, public spaces in hotels and hospitals, staircases and landings, theatres, cinemas, restaurants, and grandstands	100 (100)	,,
(vi)	Warehouses, book and stationery stores, and garages for vehicles over 2 tons; the actual load to be calculated but in no case less than	200 (200)	2 (3/8)*

8a.† **ROOF LOADS** (L.C.C. § 4).

(i) Flat roofs (slope not exceeding 20°) to be taken as carrying a superimposed load of 30 lb. per square foot of area covered (50 lb. for slabs, etc.).

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* Except for garages under this head. For these, the B load is to be taken as 1½ times the "maximum possible combination of wheel loads, but each wheel load not less than 1 ton."

† As amended April, 1938.

(ii) For roofs of a slope exceeding 20°, assume for *snow* a minimum superimposed load of 5 lb. per square foot of horizontal projection ; and a horizontal wind pressure of 15 lb. per square foot of vertical surface, with a suction on the leeward side of 10 lb. (the latter prescription applies only to the design of the roof structure).

The effects of wind pressure are to be computed with and without suction and with and without snow.

8b. COLUMN LOADS (L.C.C. § 4).

In buildings of over two storeys, and with superimposed loads of less than 100 lb. per foot super, the lower columns, foundations, piers, and walls may be designed to carry the following proportions of the superimposed loads :—*

Roof ...	100%
Top storey ...	100%
Next storey below ...	90%
do.	80%
do.	70%
do.	60%
All lower storeys ...	50%

9. WIND PRESSURE (L.C.C. § 6).

(i) Wind pressure may be disregarded where the height of a building is less than twice the width, if adequately stiffened by floors and walls.

(ii) Otherwise, wind pressure is to be taken (in Great Britain) as not less than 15 lb. per square foot horizontal on the upper two-thirds of the height, plus a further 10 lb. upon all projections above the general roof level. These allowances to be increased on the sea coast and in similarly exposed positions. But see also §18 below.

PART V. WORKING STRESSES.

10. STRESSES (L.C.C. § 81).

The following are the maximum stresses allowed† (the figures in brackets are for High Tensile Steel to B.S.S 548) :—

(i) Tension, in beams, etc....	8 (12) tons per sq. inch		
(ii) Compression, in beams...	do.	do.	
(iii) Shear stress : in webs ...	5 (7½) tons	do.	

with suitable provision against buckling of thin webs. For web stiffeners of plate girders, see §23.

(iv) Shop Rivets and Turned Bolts, 6 (9) tons single shear, 12 (18) tons bearing, and 5 (7½) tons in tension.

(v) Field Rivets : 5 (7½) tons single shear, 10 (15) tons bearing, 4 (6) tons in tension.

(vi) Black Bolts : 4 (6) tons single shear, 8 (12) tons bearing, 5 (7½) tons in tension. No bolts to be under ⅝″ diameter.

N.B.—In double shear, the permissible load on bolts and rivets is twice that allowed in single shear.

See also §12 (for filler joists), §18 (wind pressure), and following paragraph for beams of which the span exceeds 20 times the flange width.

10. LATERAL STABILITY OF BEAMS. (L.C.C. § 81).

Where the compression flange of a beam is not supported laterally and the unsupported length exceeds 20 flange widths, the working stress is to be reduced to $11 - 0{\cdot}15$ L/b tons per square inch (for high tensile steel $16{\cdot}5 - 0{\cdot}25$ L/b).

* On the assumption that the floors will not all be fully loaded at the same time.

† But see page 6 for War Emergency stresses.

N.B.—The first of these formulæ is equivalent to reducing the ordinary 8 tons stress by rather less than the following percentages :

For ratio l/b =	25	30	35	40	45	50
Reduction =	10%	20%	30%	40%	50%	60%

The stress reduction for high tensile steel is a little greater.

The unsupported length must in no case exceed 50b.

11. **GRILLAGE BEAMS** (L.C.C. §82).

The stresses in § 10 may be increased by 50% ($33\frac{1}{3}$% for high tensile steel) if completely embedded—with at least 4″ cover above and on sides—in an approved concrete,[1] solidly tamped, and the beams spaced at least 3 inches apart.

12. **FILLER BEAMS** (L.C.C. §§ 83, 84).

These, if entirely encased in concrete, may be calculated as composite beams and stressed to 9 tons per square inch (see table of Resistance Moments, page 229), or 12 tons for high tensile steel. The maximum spacing without suitable reinforcement to be six times the slab thickness.

Alternatively, the extreme fibre stress, calculated on the filler joists alone, may be increased to $9 + t$ (or $13 + 1\frac{1}{4}\, t$ for high tensile steel) where t equals thickness of concrete above the top flange ; but t must not be taken as more than 3. The span must not exceed 32 times the effective depth.

13. **OTHER ENCASED BEAMS** (L.C.C. §§ 68, 81).

In beams with rectangular concrete encasement (other than filler and grillage beams) the stress, calculated as plain steel, may be increased to $8\frac{1}{2}$ tons per square inch ($12\frac{3}{4}$ tons for high tensile steel) where (i) the minimum width of solid casing is 4″ greater than the flange width of the beam, (ii) the beam is laterally supported by a concrete slab without adjacent openings, and (iii) the upper surface of the steel beam is at least $1\frac{1}{2}$″ below and $2\frac{1}{2}$″ above the upper and lower surfaces respectively of the slab.

14. **DEFLECTION AND MAXIMUM SPANS** (L.C.C. § 84).

The span must not exceed 24 times (16 times for high tensile steel) the depth of a beam, unless the calculated deflection is less than 1/325th of the span ; except with filler beams, § 12 above.

15. **COLUMN STRESSES** (L.C.C. § 85a).

The ratio l/g is limited to 150 in main members, 240 in subsidiary members (200 in L.C.C. § 85). This section specifies the allowable stresses. These are tabulated on page 95, with intermediate values obtained, as directed, by interpolation.

16. **EFFECTIVE LENGTH OF COLUMN** (L.C.C. §§ 86 to 90).

For determining axial stress, the effective length is to be computed as follows :—

(*a*) Both ends held in position and restrained in direction, 0·7 of the actual length.

(*b*) Both ends held in position and one end restrained in direction, 0·85 of the actual length.[2]

(*c*) Both ends held in position, but unrestrained in direction, the actual length.[3]

(*d*) One end held in position and restrained in direction, the other end restrained in direction but not held in position, 1 to $1\frac{1}{2}$ times the actual length, depending on the degree of restraint.

The end of a column may generally be assumed to be ***restrained in direction*** if the

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[1] The British Standard Specification says a "fine" concrete. The L.C.C. specifies concrete of grade iv or richer *i.e.*, not exceeding $7\frac{1}{2}$ cubic feet of aggregate per cwt. of Portland cement.

[2] The actual length of each column in a building of two or more storeys is taken as the length between the centres of lateral support.

[3] If partially restrained, an intermediate value may be taken (§ 16, iv).

resistance moment of the restraining member(s) and connection(s) equals :—

(i) 0·25 of the resistance moment of the column section calculated as a beam with an extreme fibre stress of 8 tons per sq. inch[1] for l/g ratios up to 120,

(ii) 0·25 + 0·02 (l/g—120) of the resistance moment of the compression member for values of l/g exceeding 120, where l = effective length and g = radius of gyration about the axis under consideration.

For a column to be considered continuous through a *spliced joint*, the moment of resistance at the cross section of the splice must comply with the foregoing limits. In such a case, a column may be considered to be " restrained in direction " if the resistance moment of the supporting member is not less than *one-half* of the above-mentioned limits.

A column having a *flat or square end* fixed in position[2] can be assumed—for the purpose of computing its effective length—to have an end connection with a resistance moment equal to one-fourth of its own. It can be considered effectively " restrained " (as regards crippling due to axial load) if its length is not over 120 l/g, otherwise only partially restrained.

17. ECCENTRIC LOADING ON COLUMNS (L.C.C. §§ 87 to 90).

(i) The calculated maximum stress may exceed the ordinary working stress of § 15 according to a formula given. If W = actual load, then Fc = W/a ; and if F_1 is the ordinary working stress of § 15, the increased stress allowable is determined by the ratio Fc/F_1. *E.g.*, if l/g = 96, F_1 = 4 ; so that, if Fc = 2, Fc/F_1 = 50%. Then, by the formula (or, in practice, from the charts given in the appendix) it will be seen that the maximum compressive stress may be taken as 5 instead of the normal 4 tons per sq. inch.

(ii) Bending Moment induced by a beam may be regarded as divided between the column lengths above and below the beam in proportion to their stiffness (I/l), " account being taken of all bending or shearing forces at any joint."

(iii) Bending Moments due to eccentric loading at a given floor level may be disregarded at other levels if the column is " effectively restrained in relation to the eccentric load " at the adjacent floor levels.

18.† STRESSES DUE TO WIND (L.C.C. § 90).

The normal working stresses given in §§ 10, 13, 15, 17 (including stresses in roof trusses, purlins, and their connections) may be increased by one-third where the increased stress is induced solely by wind pressure.

PART VI. DETAILS OF CONSTRUCTION.

19. MINIMUM THICKNESS OF STEEL. (L.C.C. §§ 80 and 106).

The minimum thickness allowed is 5/16″ in external, ¼″ in internal construction. These limits are not applicable to light work (defined), nor to rolled sections or packings. The webs and flanges of built-up columns must not be under ⅜″ thick (5/16″ for H.T. steel).

20/22. EFFECTIVE SPAN, DEPTH AND SECTIONAL AREA.

Span is defined in § 20. By § 21, the effective depth of a plate girder is to be taken as the distance between the centres of gravity of the flanges, or the depth over the angles, whichever is the less.

By § 22, the nett sectional area is to be taken for tension members ; and for compression members if subject also to tension. Shear stress is to be calculated on the depth of the web plate in a plate girder ; on the full depth of the section in a rolled steel beam or channel.

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[1] For high tensile steel, 12 tons per sq. inch.
[2] And capable of distributing the load uniformly over its sectional area.
† As amended April, 1938.

23. **PLATE GIRDERS**

This section gives detailed provisions for the design of plate girders, including the provision of intermediate stiffeners whenever the unsupported depth of the web plate is more than 60 times its thickness.

24. **SOLID ROUND COLUMNS** (L.C.C. § 73).

These are to have machined shouldered ends to receive the caps and bases, which are to be shrunk or screwed on before machining the bearing surfaces. The length or diameter of the cap or baseplate is not to be less than $1\frac{1}{2}$ $(d + 3)$, where d is the diameter of the reduced end. A formula is given for determining the minimum thickness of the caps and bases, giving results ranging from $\frac{1}{2}$ d for light columns to d for heavy columns.

25. **STANCHION CAPS AND BASES** (L.C.C. §§ 69 to 72).

The prescriptions for caps and bases other than those for solid rounds include the following :

(i) The rivets in bases need only be capable of transmitting 60% of the axial load.

(ii) Stanchion bases must be machined after riveting up complete. But machining can be dispensed with if rivets and gussets are designed to transmit the whole load.

(iii) A formula for computing the thickness of slab bases (§ 28a).

26. **LATTICE MEMBERS.**

This section contains prescriptions governing the design of latticed columns, of columns joined by batten plates, and of tension members with intermediate tie plates.

27. **RIVETS** (L.C.C. §§ 77 to 79).

This section prescribes the minimum and maximum pitch of rivets, minimum distances from edge of plate, etc. The effective diameter of a rivet may be taken to be that of the finished rivet, *i.e.*, the diameter of the rivet hole.

PART VII. FABRICATION AND ERECTION.

28. **PREVENTION OF CORROSION.**

This is referred to briefly in general terms. Protection from corrosion is largely secured by the provisions for protection against fire (B.S.S. 476 ; L.C.C. §§ 66 to 68).

29. **FABRICATION** (L.C.C. §§ 74 to 76).

This is to be done in the shops as far as possible. Black bolts may be used in site connections only if suitable dead bearings are provided to resist all shear forces involved (but dead bearings are not required for roof trusses or secondary floor beams). Washers are to be used under all nuts, and on tapered surfaces washers must be used under bolt heads also. § 29c prescribes that any welding must conform with British Standard Specification 538 for arc-welding, 693 for gas-welding.

APPENDIX: OTHER MATERIALS.

Appended to B.S.S. 449 are notes on materials other than steel : these notes are not to be considered as part of the specification. They include notes and recommendations on the following points :—

A. **WALLS.**

B. **MATERIALS** (L.C.C. Part II.)

Materials to conform with the current B.S. Specification, if any.

C. MORTAR (L.C.C. Part II).

D. CONCRETE (L.C.C. Part II).

For protection against corrosion, a " fine " grade concrete to be used. Breeze and clinker aggregates not to be used in any bearing structure or foundation, nor within 1″ of structural steel.

E. FIRE PROTECTION

The designer is referred to B.S.S. 476–1932.

F. PRESSURES ON CONCRETE (L.C.C. §§ 14, 34, 35).

This section gives safe bearing pressures per square foot for various mixtures.

For *fine* concrete, the pressures range from 40 tons per sq. foot for 1 : 1 : 2 (2½ cubic feet of aggregate and 1 of sand to 1 cwt. of cement) to 30 tons per sq. foot for 1 : 2 : 4 (5 cubic feet of aggregate and 2½ of sand to 1 cwt. of cement).

For *mass* concrete, the pressures are :—

1 : 6	20 tons per sq. foot.	1 : 10	10 tons per sq. foot.
1 : 8	15 ,, ,, ,,	1 : 12	5 ,, ,, ,,

(These grades are defined as containing 7½, 10, 12½, and 15 cubic feet of aggregate respectively, per cwt. of cement.)

For purely local pressure, as at girder bearings, the specified pressures may be increased by 20%.

In column foundations, where the depth is not less* than 1½ times the length or breadth, the pressures may be increased by from 33⅓% to 100% according to the size of the foundation in relation to the column base. The angle of dispersion (for unreinforced concrete) may not be taken to be more than 45°.

F, G, H. BRICKWORK AND MASONRY (L.C.C. §§ 18, 19).

A table of " Permissible pressures on Masonry " gives the allowable pressures on brickwork and masonry according to the ascertained crushing strength of the material and the quality of the mortar ; also the appropriate reductions for pieces of which the height is more than 6 times the width or thickness.

J. PRESSURE ON SOIL (L.C.C. § 30).

Approximate figures, to be confirmed by trial borings, are given for safe pressures on the subsoil. Typical examples are :—Made ground ½ ton, firm dry clay 3 tons, hard solid chalk 6 tons, hard rock 40 tons per sq. foot.

K, L, M. TESTS (L.C.C. Schedules I, II, and III).

These sections prescribe methods of testing Concrete for crushing strength and consistence K,L), and Bricks and Stone (M).

* The specification says " greater "; obviously a clerical error.

EXTRAS.

The extras quoted in this chapter are those ruling in Dec., 1947, and are liable to alteration without notice. Those given for Broad Flange Beams, Grey Process, apply solely to British markets (higher extras are chargeable in other markets) and are subject to possible additions for *ad valorem* duty if any.

The extras for Broad Flange Beams, Grey Process—given in detail on pages 287 to 288—are summarised below.

BROAD FLANGE BEAMS, GREY PROCESS.

Nominal Depth.	Section Extra.	Exact Lengths.[1]	Tests or Inspection.	Painting one coat.	Oiling one coat.	Drilling.[2]		Minimum Lots.	
						Web.	Flange.	DIN weights.	Intermediate weights.
Inches.	Per ton.	Per bar.	Per ton.	Per ton.	Per ton.			Tons.	Tons.
4″ and 5″	10/0	12/0		20/0	12/0			3	18
5½″ to 7″	...	12/0		20/0	12/0			3	18
8″	...	12/0		20/0	12/0			4	22
8½″ to 10″	...	16/0		20/0	12/0			4	22
10¼″ to 12″	...	16/0	[See page 288]	20/0	12/0	[See below]		5	25
12½″ to 14″	20/0	20/0		15/0	10/0			5	25
15″ to 19″	20/0	20/0		15/0	10/0			7	30
20″	40/0	25/0		15/0	10/0			7	30
22″ to 30″	40/0	25/0		15/0	10/0			9	36
32″ to 40″	60/0	32/0		15/0	10/0			9	36

[1]. Higher extras are chargeable for "exact" cutting of sections exceeding the "DIN" weights; see § 6 opposite.

[2]. The charges for Drilling, quoted on application, vary according to section and weight per foot of beam, and diameter of hole; from about 3d. to 6d. each in web, 5d. to 9d. in flanges, plus 5s. 0d. per ton for handling.

These rates are for ordinary round holes up to 1½ inches or 40 mm. diameter; oval, slotted, or countersunk holes are about twice the foregoing rates.

EXTRAS—Continued.

BROAD FLANGE BEAMS, GREY PROCESS.

1. GREY PROCESS.

These beams should be specified as " Broad Flange Beams, Grey Process."

2. SIZES.

The " nominal " sizes of Broad Flange Beams, Grey Process, are only approximate. The exact dimensions are given in the various tables under the heading " Exact Sizes " ; these are subject of course to the customary rolling margins or tolerances (see page 268). The metric dimensions are given on pages 23–26.

3. SECTION EXTRAS.

Sections 4″ to 5″ nominal	... ...	10s. 0d. per ton extra.
,, 5½″ to 12″ ,,	... ...	Supplied at basis price.
,, 12½″ to 19″ ,,	... ...	20s. 0d. per ton extra.
,, 20″ to 30″ ,,	... ...	40s. 0d. ,, ,, ,,
,, 32″ to 40″ ,,	... ...	60s. 0d. ,, ,, ,,

The section extra depends upon the *nominal* depth. For example, the 12″ Dir section, although 13¼″ deep, is supplied without extra.

4. COLD STRAIGHTENING.

Broad Flange Beams are always straightened (when necessary) free of charge before leaving the Works. When exceptional precision is required, " double straightening " is sometimes specified, at an extra of 12s. 0d. per ton.

5. CUTTING TO LENGTHS.

Beams are cut to lengths, by hot-saw or otherwise, within 4″ over, without extra charge.

6. EXACT LENGTHS AND SQUARE ENDS.

Beams can be cut to " exact " lengths, both ends square, within a margin of 1/8″ under and over, at the following extras. (If the margin is to be taken one way only, it must be increased to 1/4″) :—

Sections up to 8″ deep	... ...	12s. 0d. per length.
,, over 8″ to 12″ deep	... ...	16s. 0d. ,, ,,
,, ,, 12″ ,, 19″ ,,	... ...	20s. 0d. ,, ,,
,, ,, 19″ ,, 30″ ,,	... ...	25s. 0d. ,, ,,
,, ,, 30″ ,, 40″ ,,	... ...	32s. 0d. ,, ,,

[The treatment is to hot-saw only a little over the specified lengths, and then to mill the ends at the fraising machine down to the " exact " lengths. Consequently, unless the required finished lengths are known *before rolling*, additional labour, and a corresponding extra charge, may be incurred.]

If it will suffice for *one* end to be squared, and a margin in length of 1/4″ under and over measured along the axis of the beam can be allowed, the above-mentioned extras will be reduced by 50%. This procedure is not suitable if the beams are to be drilled at both ends. Special extras are charged for *bevel* cuts.

N.B.—In the case of the Dir Sections (Maximum weights), the extras for " exact " lengths are determined by the *actual* depth of the section.

7. MINIMUM AND MAXIMUM LENGTHS.

All sections can be rolled in lengths up to 100 feet or more. Lengths under 10 feet or over 49 feet are charged extra. Pieces over 30 feet or weighing over 2 tons usually incur freight extras. Very heavy pieces are also liable to extras for cranage at port of shipment.

BROAD FLANGE BEAMS, GREY PROCESS.

8. QUALITIES.
For available qualities, and quality extras, see page 267.

9. TEST CERTIFICATE OR INSPECTION.
In addition to the quality extras given on page 267, there will be an extra 4s. 0d. per ton for test certificate (if required); or 10s. 0d. per ton if tested and inspected by the buyer's representative. These extras are to cover the cost of tensile tests and handling, and do not include the inspector's fees.

10. ROLLING MARGIN. See page 268.

11. PAINTING AND OILING.

Sections up to 12″	...	Oiling, 12s. 0d., painting, 20s. 0d. per ton, for one coat.
,, $12\frac{1}{2}$″ to 40″	...	,, 10s. 0d., ,, 15s. 0d. ,, ,, ,, ,, ,,

12. DRILLING. See page 286.

13. NOTCHING, CLEATING, &c.
This can be undertaken in suitable cases at extras to be arranged.

14. SHIPPING MARKS.
Elaborate marking will be charged extra.

15. TIME REQUIRED FOR DELIVERY.
In the various tables of sizes and safe loads, each section is marked with a *letter* indicating the time required for delivery (in normal times); these symbols are to be interpreted as follows :—

* Stocked in London, Dewsbury and Glasgow, etc. (but see p. 6).
a Rolled at intervals of about 3/4 weeks.
b ,, ,, ,, ,, ,, 4/6 ,,
c ,, ,, ,, ,, ,, 6/8 ,,

These indications are only intended to give an approximate idea of the time required for delivery, which will vary according to the state of trade, and tonnage required. Thus, rolls can usually be mounted *specially* for lots of 100 tons or more of a single section; so that, as the capacity of the Mill is 500 to 1,000 tons per day, large orders can often be rolled at very short notice. The smaller quantities normally specified can only be rolled as the rolls go in for the various sections; except that *small* lots of most sizes can usually be supplied from stock at mills—in " Stock " quality, i.e., mild steel of good quality not sold to specific tests.

To the time required for rolling, a further allowance must be made for carriage from mills to destination; this averages two weeks to all parts of the United Kingdom. Time must also be allowed for any painting, drilling, or other workmanship required.

EXTRAS—Continued.

JOISTS, CHANNELS, ANGLES, TEES, FLATS.

Dec. 1947.

The following were the standard British extras in Dec., 1947, and are liable to alteration without notice. All are per ton of 2240 lb. They are the " heavy " steelworks' extras ; lighter sections come under the re-rollers' extras list and command a higher basis price.

JOISTS

Size.	Extra.	Size.	Extra.	Size.	Extra.
3" × 1½"	70/–	5" × 2½"	15/–	16" × 8"	10/–
3" × 3"	25/–	5" × 3"	10/–	18" × 6"	10/–
3½" × 3½"	10/–	6" × 3"	7/6	18" × 7"	10/–
4" × 1¾"	50/–	—	—	18" × 8"	10/–
4" × 2½"	20/–	9" × 7"	5/–	20" × 6½"	10/–
4" × 3"	20/–	10" × 8"	10/–	20" × 7½"	10/–
4" × 4"	10/–	12" × 8"	10/–	22" × 7"	15/–
4¾" × 1¾"	30/–	14" × 8"	10/–	24" × 7½"	20/–

It will be seen that the basis sizes are 5" × 4½" to 16" × 6" ; excepting 6" × 3", and the wide-flanged sections 9" × 7", 10" × 8", 12" × 8", and 14" × 8".

CHANNELS

Sizes.	Web Thickness.		
	5/16" and up.	Under 5/16" to 1/4"	Under 1/4" to 3/16".
Under 4" and over 3"	35/–	52/6	60/–
Under 5" to 4"	25/–	35/–	40/–
Under 6" to 5"	12/6	17/6	22/6
6" to 12", flanges 3" and up	5/–	7/6	10/–
Over 12" to 15", flanges 3" and up	10/–	12/6	15/–
Over 15" to 15¾", flanges 3" and up	15/–	17/6	20/–
Over 15¾", flanges 3" and up	20/–	22/6	25/–

ANGLES

Size : United Inches.	Thickness.				
	3/8" and over.	Under 3/8" to 5/16".	Under 5/16" to 1/4".	Under 1/4" to 3/16".	Under 3/16" to 1/8".
7 to 12	basis	5/–	10/–	15/–	25/–
Under 7 to 6	12/6	17/6	22/6	30/–	40/–
Under 6 to 5	25/–	30/–	35/–	40/–	50/–
Under 5 and over 4	35/–	40/–	45/–	55/–	70/–

With Unequal Angles, if the difference in length of flanges exceeds 1 inch : 5/– per ton, in addition to the above.
Angles over 12 united inches : 5/– per ton extra per inch or part, in addition to the thickness extras above.

TEES

As for Angles, plus 20/– per ton ; with the following additional extras for Unequal Tees :—

Stalk longer than table .. .. 10/– per ton.
Stalk thicker than table .. .. 20/– " "

[Continued overleaf.]

Weights, Measures
Math. tables
Index, Code.

EXTRAS—Continued.

FLATS

Width.	Thickness.			
	1/2″ and over.	Under 1/2″ to 3/8″.	Under 3/8″ to 5/16″.	Under 5/16″ to 1/4″.
8″ and wider	5/–	12/6	17/6	22/6
Under 8″ to 7″	10/–	17/6	22/6	27/6
Under 7″ to 6″	17/6	25/–	30/–	35/–
Under 6″ to over 5″	25/–	32/6	37/6	42/6

The foregoing are the additions to be made to the current basis price of Angles; it will be observed that the minimum extra for Flats is 5/– per ton.

Specially thick flats, with square edges, over 5″ to under 12″ wide, command the following extras in addition to the aforementioned minimum 5/– extra for Flats:—

Over $1\frac{3}{4}$″ to 3″ thick .. .. .. 20/– per ton.
„ 3″ „ 5″ „ .. .. .. 30/– „ „

QUALITY: Extra per ton.
Boiler quality 10/–
Boiler quality to pass Board of Trade or Admiralty Survey 20/–

SURFACE INSPECTION: 5/–

LENGTH:
Joists over 50 ft., per ft. or part 1/–
Channels, Angles and Tees over 60 ft. per ft. or part 1/–
Flats over 40 ft. per ft. or part 1/6

SHORT LENGTHS: (All Shapes).
Under 10ft. to 5ft. 2/6
„ 5 „ 3 „ 10/–

COLD STRAIGHTENING:
Joists cold straightened free of charge. Channels 6″ and over 3/6
Angles and Tees 6 united inches and over 3/6
Flats 6″ and over 3/6

PAINTING, OILING or CEMENT WASHING:
Extras quoted on application.

SMALL LOTS:
Under 1 ton of a size or thickness 20/–

EXACT LENGTHS:
Cold sawing to within $\frac{1}{8}$″ margin, inclusive of any extras for short lengths under 10 ft. and cold straightening, for each pound per foot in weight of section, 1d. per bar.
(*E.g.* for cold sawing a 6″ × 3″ Joist weighing 12 lb. per foot the extra for "exact lengths" is 1/– per bar.) This extra does not necessarily include squaring *both* ends.

WEIGHTS AND MEASURES.

Weights, Measures

Math. tables.

Index, Code.

BRITISH AND METRIC EQUIVALENTS ETC.

To convert	Into	Multiply by	Log.	Divide by	Log.	Amplified on Page
LINEAR MEASURE.						
Inches	Millimetres	25·4000	*404833*	0·03937	*595167*	294–297
,, ...	Metres	0·02540	*404833*	39·3701	*595167*	293, 296
Feet	,, ...	0·30480	*484015*	3·28084	*515986*	,,
Yards	,, ...	0·91440	*961136*	1·09361	*038864*	305
Miles	Kilometres	1·60934	*206649*	0·62137	*793352*	,,
SQUARE MEASURE.						
Square Inches ...	Square Centimetres ...	6·45159	*809667*	0·15500	*190333*	298—299
,, Feet ...	,, Metres ...	0·09290	*968029*	10·7639	*031971*	299
,, Yards ...	,, ,, ...	0·83613	*922272*	1·19599	*077728*	305
Acres...	,, ,, ...	4046·85	*607117*	0·00025	*392883*	,,
Square Miles ...	,, Kilometres ...	2·58998	*413297*	0·38610	*586703*	,,
CUBIC MEASURE.						
Cubic Inches ...	Cubic Centimetres ...	16·3870	*214500*	0·06102	*785500*	298—299
,, Feet	,, Metres	0·02832	*452044*	35·3148	*547956*	299
,, Yards... ...	,, ,, ...	0·76455	*883408*	1·30795	*116592*	305
Pints	Litres	0·56825	*754537*	1·75980	*245463*	,,
Gallons	,, ...	4·54596	*657626*	0·21998	*342374*	,,
QUARTIC MEASURE.						
Inches[4]	Centimetres[4]	41·6230	*619333*	0·02403	*380667*	—
WEIGHT.						
Ounces	Grammes	28·3495	*452546*	0·03527	*547454*	305
Pounds	Kilogrammes... ...	0·45359	*656666*	2·20462	*343334*	300—301
Cwts....	,, ...	50·8023	*705884*	0·01968	*294116*	304
Tons	,, ...	1016·05	*006914*	0·00098	*993086*	,,
WEIGHT PER LENGTH.						
Pounds per foot ...	Kilos. per metre ...	1·48817	*172651*	0·67197	*827349*	300
,, ,, yard ...	,, ,, ,, ...	0·49606	*695530*	2·01590	*304470*	—
PRESSURES ETC.						
Pounds per sq. inch	Kilos. per sq. mm. ...	0·00070	*846999*	1422·33	*153001*	272, 300
,, ,, ,, foot	,, ,, ,, cm. ...	0·00049	*688637*	2048·16	*311363*	—
Tons per sq. inch ...	,, ,, ,, mm. ...	1·57488	*197247*	0·63497	*802753*	272
,, ,, ,, foot ...	Lb. per sq inch ...	15·5556	*191886*	0·06429	*808115*	—
,, ,, ,, ,, ...	Kilos. per sq. cm. ...	1·09367	*038885*	0·91436	*961115*	—
Tons per acre ...	Kilos. per hectare ...	2510·71	*399797*	0·00040	*600203*	—
Foothead of water ...	Lb. per sq. inch ...	0·43256	*636044*	2·31183	*363956*	—
WEIGHT × LENGTH.						
Foot-pounds ...	Kilogram-metres ...	0·13825	*140680*	7·23302	*859320*	—
Inch-tons	,, ,, ...	25·8076	*411747*	0·03875	*588253*	—
Foot-tons	,, ,, ...	309·691	*490928*	0·00323	*509072*	—
VELOCITY.						
Miles per hour ...	Feet per second ...	1·46667	*166331*	0·68182	*833669*	—
Kilometres per hour	,, ,, ,, ...	0·91135	*959683*	1·09728	*040317*	—

The above figures are calculated from the British legal equivalents (1898), *viz.*, 1 metre = 39·370113 inches; 1 kilogram = 2·2046223 pounds; 1 gallon = 4·5459631 litres.

The weight of steel in pounds per foot is 3·4 times the sectional area in square inches.

The weight of steel in kilos. per metre is usually taken as ·785 times the sectional area in square centimetres, but the correct figure is ·7843 approx.

The British gallon is the volume occupied by 10 lb. of pure water of a certain temperature etc. This is as nearly as possible 277·42 cubic inches. Hence, 1 cubic foot of water equals 6·23 gallons. Pure water weighs 62·3 lb., and sea water approx. 64 lb. per cubic foot. The United States gallon (liquid measure) is only 231 cubic inches, *viz.*, 5/6ths of the British gallon.

FEET AND INCHES INTO METRES.

For intermediate lengths, involving fractions, take the equivalent of the inches from the table on page 296; thus, 41′ 4¾″ = 2,497 + 0,121 = 12,618 metres.

Feet.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	Feet.
0	0	0,025	0,051	0,076	0,102	0,127	0,152	0,178	0,203	0,229	0,254	0,279	0
1	0,305	0,330	0,356	0,381	0,406	0,432	0,457	0,483	0,508	0,533	0,559	0,584	1
2	0,610	0,635	0,660	0,686	0,711	0,737	0,762	0,787	0,813	0,838	0,864	0,889	2
3	0,914	0,940	0,965	0,991	1,016	1,041	1,067	1,092	1,118	1,143	1,168	1,194	3
4	1,219	1,245	1,270	1,295	1,321	1,346	1,372	1,397	1,422	1,448	1,473	1,499	4
5	1,524	1,549	1,575	1,600	1,626	1,651	1,676	1,702	1,727	1,753	1,778	1,803	5
6	1,829	1,854	1,880	1,905	1,930	1,956	1,981	2,007	2,032	2,057	2,083	2,108	6
7	2,134	2,159	2,184	2,210	2,235	2,261	2,286	2,311	2,337	2,362	2,388	2,413	7
8	2,438	2,464	2,489	2,515	2,540	2,565	2,591	2,616	2,642	2,667	2,692	2,718	8
9	2,743	2,769	2,794	2,819	2,845	2,870	2,896	2,921	2,946	2,972	2,997	3,023	9
10	3,048	3,073	3,099	3,124	3,150	3,175	3,200	3,226	3,251	3,277	3,302	3,327	10
11	3.353	3,378	3,404	3,429	3,454	3,480	3,505	3,531	3,556	3,581	3,607	3,632	11
12	3,658	3,683	3,708	3,734	3,759	3,785	3,810	3,835	3,861	3,886	3,912	3,937	12
13	3,962	3,988	4,013	4,039	4,064	4,089	4,115	4,140	4,166	4,191	4,216	4,242	13
14	4,267	4,293	4,318	4,343	4,369	4,394	4,420	4,445	4,470	4,496	4,521	4,547	14
15	4,572	4,597	4,623	4,648	4,674	4,699	4,724	4,750	4,775	4,801	4,826	4,851	15
16	4,877	4,902	4,928	4,953	4,978	5,004	5,029	5,055	5,080	5,105	5,131	5,156	16
17	5,182	5,207	5,232	5,258	5,283	5,309	5,334	5,359	5,385	5,410	5,436	5,461	17
18	5,486	5,512	5,537	5,563	5,588	5,613	5,639	5,664	5,690	5,715	5,740	5,766	18
19	5,791	5,817	5,842	5,867	5,893	5,918	5,944	5,969	5,994	6,020	6,045	6,071	19
20	6,096	6,121	6,147	6,172	6,198	6,223	6,248	6,274	6,299	6,325	6,350	6,375	20
21	6,401	6.426	6,452	6,477	6,502	6,528	6,553	6,579	6,604	6,629	6,655	6,680	21
22	6,706	6,731	6,756	6,782	6,807	6,833	6,858	6,883	6,909	6,934	6,960	6,985	22
23	7,010	7,036	7,061	7,087	7,112	7,137	7,163	7,188	7,214	7,239	7,264	7,290	23
24	7,315	7,341	7,366	7,391	7,417	7,442	7,468	7,493	7,518	7,544	7,569	7,595	24
25	7,620	7,645	7,671	7,696	7,722	7,747	7,772	7,798	7,823	7,849	7,874	7,899	25
26	7,925	7,950	7,976	8,001	8,026	8,052	8,077	8,103	8,128	8,153	8,179	8,204	26
27	8,230	8,255	8,280	8,306	8,331	8,357	8,382	8,407	8,433	8,458	8,484	8,509	27
28	8,534	8,560	8,585	8,611	8,636	8,661	8,687	8,712	8,738	8,763	8,788	8,814	28
29	8,839	8,865	8,890	8,915	8,941	8,966	8,992	9,017	9,042	9,068	9,093	9,119	29
30	9,144	9,169	9,195	9,220	9,246	9,271	9,296	9,322	9,347	9,373	9,398	9,423	30
31	9,449	9,474	9,500	9,525	9,550	9,576	9,601	9,627	9,652	9,677	9,703	9,728	31
32	9,754	9,779	9,804	9,830	9,855	9,881	9,906	9,931	9,957	9,982	10,008	10,033	32
33	10,058	10,084	10,109	10,135	10,160	10,185	10 211	10,236	10,262	10,287	10,312	10,338	33
34	10,363	10,389	10,414	10,439	10,465	10,490	10,516	10,541	10,566	10,592	10,617	10,643	34
35	10,668	10,693	10,719	10,744	10,770	10,795	10,820	10,846	10,871	10,897	10,922	10,947	35
36	10,973	10,998	11,024	11,049	11,074	11,100	11,125	11,151	11,176	11,201	11,227	11,252	36
37	11,278	11,303	11,328	11,354	11,379	11,405	11,430	11,455	11,481	11,506	11,532	11,557	37
38	11,582	11,608	11,633	11,659	11,684	11,709	11,735	11,760	11,786	11,811	11,836	11,862	38
39	11,887	11,913	11,938	11,963	11,989	12,014	12,040	12,065	12,090	12,116	12,141	12,167	39
40	12,192	12,217	12,243	12,268	12,294	12,319	12,344	12,370	12,395	12,421	12,446	12,471	40
41	12,497	12,522	12,548	12,573	12,598	12,624	12,649	12,675	12,700	12,725	12,751	12,776	41
42	12,802	12,827	12,852	12,878	12,903	12,929	12,954	12,979	13,005	13,030	13,056	13,081	42
43	13,106	13,132	13,157	13,183	13,208	13,233	13,259	13,284	13,310	13,335	13,360	13,386	43
44	13,411	13,437	13,462	13,487	13,513	13,538	13,564	13,589	13,614	13,640	13,665	13,691	44
45	13,716	13,741	13,767	13,792	13,818	13,843	13,868	13,894	13,919	13,945	13,970	13,995	45
46	14,021	14,046	14,072	14,097	14,122	14,148	14,173	14,199	14,224	14,249	14,275	14,300	46
47	14,326	14,351	14,376	14,402	14,427	14,453	14,478	14,503	14,529	14,554	14,580	14,605	47
48	14,630	14,656	14,681	14,707	14,732	14,757	14,783	14,808	14,834	14,859	14,884	14,910	48
49	14,935	14,961	14,986	15,011	15,037	15,062	15,088	15,113	15,138	15,164	15,189	15,215	49
50	15,240	15,265	15,291	15,316	15,342	15,367	15,392	15,418	15,443	15,469	15,494	15,519	50

Feet	60	70	80	90	100	150	200	300	400	500	1000	Feet
Metres	18,288	21,336	24.384	27,432	30,480	45,720	60,960	91,440	121,920	152,400	304,801	Metres

MILLIMETRES INTO INCHES.

To convert decimals into vulgar fractions, see Table on page 297.

1 mm. = 0·039370 inch.

Mm.	0	1	2	3	4	5	6	7	8	9	Mm.
0	...	0·039	0·079	0·118	0·157	0·197	0·236	0·276	0·315	0·354	0
10	0·394	0·433	0·472	0·512	0·551	0·591	0·630	0·669	0·709	0·748	10
20	0·787	0·827	0·866	0·906	0·945	0·984	1·024	1·063	1·102	1·142	20
30	1·181	1·220	1·260	1·299	1·339	1·378	1·417	1·457	1·496	1·535	30
40	1·575	1·614	1·654	1·693	1·732	1·772	1·811	1·850	1·890	1·929	40
50	1·969	2·008	2·047	2·087	2·126	2·165	2·205	2·244	2·283	2·323	50
60	2·362	2·402	2·441	2·480	2·520	2·559	2·598	2·638	2·677	2·717	60
70	2·756	2·795	2·835	2·874	2·913	2·953	2·992	3·032	3·071	3·110	70
80	3·150	3·189	3·228	3·268	3·307	3·346	3·386	3·425	3·465	3·504	80
90	3·543	3·583	3·622	3·661	3·701	3·740	3·780	3·819	3·858	3·898	90
100	3·937	3·976	4·016	4·055	4·095	4·134	4·173	4·213	4·252	4·291	100
110	4·331	4·370	4·409	4·449	4·488	4·528	4·567	4·606	4·646	4·685	110
120	4·724	4·764	4·803	4·843	4·882	4·921	4·961	5·000	5·039	5·079	120
130	5·118	5·158	5·197	5·236	5·276	5·315	5·354	5·394	5·433	5·472	130
140	5·512	5·551	5·591	5·630	5·669	5·709	5·748	5·787	5·827	5·866	140
150	5·906	5·945	5·984	6·024	6·063	6·102	6·142	6·181	6·221	6·260	150
160	6·299	6·339	6·378	6·417	6·457	6·496	6·535	6·575	6·614	6·654	160
170	6·693	6·732	6·772	6·811	6·850	6·890	6·929	6·969	7·008	7·047	170
180	7·087	7·126	7·165	7·205	7·244	7·284	7·323	7·362	7·402	7·441	180
190	7·480	7·520	7·559	7·598	7·638	7·677	7·717	7·756	7·795	7·835	190
200	7·874	7·913	7·953	7·992	8·032	8·071	8·110	8·150	8·189	8·228	200
210	8·268	8·307	8·347	8·386	8·425	8·465	8·504	8·543	8·583	8·622	210
220	8·661	8·701	8·740	8·780	8·819	8·858	8·898	8·937	8·976	9·016	220
230	9·055	9·095	9·134	9·173	9·213	9·252	9·291	9·331	9·370	9·410	230
240	9·449	9·488	9·528	9·567	9·606	9·646	9·685	9·724	9·764	9·803	240
250	9·843	9·882	9·921	9·961	10·000	10·039	10·079	10·118	10·158	10·197	250
260	10·236	10·276	10·315	10·354	10·394	10·433	10·473	10·512	10·551	10·591	260
270	10·630	10·669	10·709	10·748	10·787	10·827	10·866	10·906	10·945	10·984	270
280	11·024	11·063	11·102	11·142	11·181	11·221	11·260	11·299	11·339	11·378	280
290	11·417	11·457	11·496	11·536	11·575	11·614	11·654	11·693	11·732	11·772	290
300	11·811	11·850	11·890	11·929	11·969	12·008	12·047	12·087	12·126	12·165	300
310	12·205	12·244	12·284	12·323	12·362	12·402	12·441	12·480	12·520	12·559	310
320	12·599	12·638	12·677	12·717	12·756	12·795	12·835	12·874	12·913	12·953	320
330	12·992	13·032	13·071	13·110	13·150	13·189	13·228	13·268	13·307	13·347	330
340	13·386	13·425	13·465	13·504	13·543	13·583	13·622	13·662	13·701	13·740	340
350	13·780	13·819	13·858	13·898	13·937	13·977	14·016	14·055	14·095	14·134	350
360	14·173	14·213	14·252	14·291	14·331	14·370	14·410	14·449	14·488	14·528	360
370	14·567	14·606	14·646	14·685	14·725	14·764	14·803	14·843	14·882	14·921	370
380	14·961	15·000	15·040	15·079	15·118	15·158	15·197	15·236	15·276	15·315	380
390	15·354	15·394	15·433	15·473	15·512	15·551	15·591	15·630	15·669	15·709	390
400	15·748	15·788	15·827	15·866	15·906	15·945	15·984	16·024	16·063	16·103	400
410	16·142	16·181	16·221	16·260	16·299	16·339	16·378	16·417	16·457	16·496	410
420	16·536	16·575	16·614	16·654	16·693	16·732	16·772	16·811	16·851	16·890	420
430	16·929	16·969	17·008	17·047	17·087	17·126	17·166	17·205	17·244	17·284	430
440	17·323	17·362	17·402	17·441	17·480	17·520	17·559	17·599	17·638	17·677	440
450	17·717	17·756	17·795	17·835	17·874	17·914	17·953	17·992	18·032	18·071	450
460	18·110	18·150	18·189	18·229	18·268	18·307	18·347	18·386	18·425	18·465	460
470	18·504	18·543	18·583	18·622	18·662	18·701	18·740	18·780	18·819	18·858	470
480	18·898	18·937	18·977	19·016	19·055	19·095	19·134	19·173	19·213	19·252	480
490	19·292	19·331	19·370	19·410	19·449	19·488	19·528	19·567	19·606	19·646	490

MILLIMETRES INTO INCHES.—Continued.

To convert decimals into vulgar fractions, see Table on page 297.

1 mm. = 0·039370 inch.

Mm.	0	1	2	3	4	5	6	7	8	9	Mm.
500	19·685	19·725	19·764	19·803	19·843	19·882	19·921	19·961	20·000	20·040	500
510	20·079	20·118	20·158	20·197	20·236	20·276	20·315	20·355	20·394	20·433	510
520	20·473	20·512	20·551	20·591	20·630	20·669	20·709	20·748	20·788	20·827	520
530	20·866	20·906	20·945	20·984	21·024	21·063	21·103	21·142	21·181	21·221	530
540	21·260	21·299	21·339	21·378	21·418	21·457	21·496	21·536	21·575	21·614	540
550	21·654	21·693	21·732	21·772	21·811	21·851	21·890	21·929	21·969	22·008	550
560	22·047	22·087	22·126	22·166	22·205	22·244	22·284	22·323	22·362	22·402	560
570	22·441	22·481	22·520	22·559	22·599	22·638	22·677	22·717	22·756	22·795	570
580	22·835	22·874	22·914	22·953	22·992	23·032	23·071	23·110	23·150	23·189	580
590	23·229	23·268	23·307	23·347	23·386	23·424	23·464	23·503	23·543	23·582	590
600	23·622	23·662	23·701	23·740	23·780	23·819	23·858	23·898	23·937	23·977	600
610	24·016	24·055	24·095	24·134	24·173	24·213	24·252	24·292	24·331	24·370	610
620	24·410	24·449	24·488	24·528	24·567	24·607	24·646	24·685	24·725	24·764	620
630	24·803	24·843	24·882	24·921	24·961	25·000	25·040	25·079	25·118	25·158	630
640	25·197	25·236	25·276	25·315	25·355	25·394	25·433	25·473	25·512	25·551	640
650	25·591	25·630	25·670	25·709	25·748	25·788	25·827	25·866	25·906	25·945	650
660	25·984	26·024	26·063	26·103	26·142	26·181	26·221	26·260	26·299	26·339	660
670	26·378	26·418	26·457	26·496	26·536	26·575	26·614	26·654	26·693	26·733	670
680	26·772	26·811	26·851	26·890	26·929	26·969	27·008	27·047	27·087	27·126	680
690	27·166	27·205	27·244	27·284	27·323	27·362	27·402	27·441	27·481	27·520	690
700	27·559	27·599	27·638	27·677	27·717	27·756	27·796	27·835	27·874	27·914	700
710	27·953	27·992	28·032	28·071	28·110	28·150	28·189	28·229	28·268	28·307	710
720	28·347	28·386	28·425	28·465	28·504	28·544	28·583	28·622	28·662	28·701	720
730	28·740	28·780	28·819	28·859	28·898	28·937	28·977	29·016	29·055	29·095	730
740	29·134	29·173	29·213	29·252	29·292	29·331	29·370	29·410	29·449	29·488	740
750	29·528	29·567	29·607	29·646	29·685	29·725	29·764	29·803	29·843	29·882	750
760	29·922	29·961	30·000	30·040	30·079	30·118	30·158	30·197	30·236	30·276	760
770	30·315	30·355	30·394	30·433	30·473	30·512	30·551	30·591	30·630	30·670	770
780	30·709	30·748	30·788	30·827	30·866	30·906	30·945	30·985	31·024	31·063	780
790	31·103	31·142	31·181	31·221	31·260	31·299	31·339	31·378	31·418	31·457	790
800	31·496	31·536	31·575	31·614	31·654	31·693	31·733	31·772	31·811	31·851	800
810	31·890	31·929	31·969	32·008	32·048	32·087	32·126	32·166	32·205	32·244	810
820	32·284	32·323	32·362	32·402	32·441	32·481	32·520	32·559	32·599	32·638	820
830	32·677	32·717	32·756	32·796	32·835	32·874	32·914	32·953	32·992	33·032	830
840	33·071	33·111	33·150	33·189	33·229	33·268	33·307	33·347	33·386	33·425	840
850	33·465	33·504	33·544	33·583	33·622	33·662	33·701	33·740	33·780	33·819	850
860	33·859	33·898	33·937	33·977	34·016	34·055	34·095	34·134	34·174	34·213	860
870	34·252	34·292	34·331	34·370	34·410	34·449	34·488	34·528	34·567	34·607	870
880	34·646	34·685	34·725	34·764	34·803	34·843	34·882	34·922	34·961	35·000	880
890	35·040	35·079	35·118	35·158	35·197	35·237	35·276	35·315	35·355	35·394	890
900	35·433	35·473	35·512	35·552	35·591	35·630	35·670	35·709	35·748	35·788	900
910	35·827	35·866	35·906	35·945	35·985	36·024	36·063	36·103	36·142	36·181	910
920	36·221	36·260	36·300	36·339	36·378	36·418	36·457	36·496	36·536	36·575	920
930	36·615	36·654	36·693	36·733	36·772	36·811	36·851	36·890	36·929	36·969	930
940	37·008	37·048	37·087	37·126	37·166	37·205	37·244	37·284	37·323	37·363	940
950	37·402	37·441	37·481	37·520	37·559	37·599	37·638	37·677	37·717	37·756	950
960	37·796	37·835	37·874	37·914	37·953	37·992	38·032	38·071	38·111	38·150	960
970	38·189	38·229	38·268	38·307	38·347	38·386	38·426	38·465	38·504	38·544	970
980	38·583	38·622	38·662	38·701	38·741	38·780	38·819	38·859	38·898	39·937	980
990	38·977	39·016	39·055	39·095	39·134	39·174	39·213	39·252	39·292	39·331	990

INCHES INTO MILLIMETRES.

For converting decimals of an inch into millimetres, see page 297.

1" = 25,4 mm. 1/8" = 3,175 mm. 1/16" = 1,587 mm. 3/64" = 1,191 mm. 1/32" = 0,794 mm. 1/64" = 0,397 mm.

Inches	0	1	2	3	4	5	6	7	8	9	10	11
... ...	0	25,40	50,80	76,20	101,60	127,00	152,40	177,80	203,20	228,60	254,00	279,40
$\frac{1}{16}$ ...	1,59	26,99	52,39	77,79	103,19	128,59	153,99	179,39	204,79	230,19	255,59	280,99
$\frac{1}{8}$	3,17	28,57	53,97	79,37	104,77	130,17	155,57	180,97	206,37	231,77	257,17	282,57
$\frac{3}{16}$ ...	4,76	30,16	55,56	80,96	106,36	131,76	157,16	182,56	207,96	233,36	258,76	284,16
$\frac{1}{4}$	6,35	31,75	57,15	82,55	107,95	133,35	158,75	184,15	209,55	234,95	260,35	285,75
$\frac{5}{16}$ ...	7,94	33,34	58,74	84,14	109,54	134,94	160,34	185,74	211,14	236,54	261,94	287,34
$\frac{3}{8}$	9,52	34,92	60,32	85,72	111,12	136,52	161,92	187,32	212,72	238,12	263,52	288,92
$\frac{7}{16}$ ...	11,11	36,51	61,91	87,31	112,71	138,11	163,51	188,91	214,31	239,71	265,11	290,51
$\frac{1}{2}$	12,70	38,10	63,50	88,90	114,30	139,70	165,10	190,50	215,90	241,30	266,70	292,10
$\frac{9}{16}$ ...	14,29	39,69	65,09	90,49	115,89	141,29	166,69	192,09	217,49	242,89	268,29	293,69
$\frac{5}{8}$	15,87	41,27	66,67	92,07	117,47	142,87	168,27	193,67	219,07	244,47	269,87	295,27
$\frac{11}{16}$ ...	17,46	42,86	68,26	93,66	119,06	144,46	169,86	195,26	220,66	246,06	271,46	296,86
$\frac{3}{4}$	19,05	44,45	69,85	95,25	120,65	146,05	171,45	196,85	222,25	247,65	273,05	298,45
$\frac{13}{16}$ ...	20,64	46,04	71,44	96,84	122,24	147,64	173,04	198,44	223,84	249,24	274,64	300,04
$\frac{7}{8}$	22,22	47,62	73,02	98,42	123,82	149,22	174,62	200,02	225,42	250,82	276,22	301,62
$\frac{15}{16}$ ...	23,81	49,21	74,61	100,01	125,41	150,81	176,21	201,61	227,01	252,41	277,81	303,21

METRES INTO FEET.

For millimetres into inches, see table on pages 294-295.

1 metre = 39,370113 inches.

Metres	0		10		20		30		40		50	
0	...		32′	9·70″	65′	7·40″	98′	5·10″	131′	2·80″	164′	0·51″
1	3′	3·37″	36′	1·07″	68′	10·77″	101′	8·47″	134′	6·17″	167′	3·88″
2	6′	6·74″	39′	4·44″	72′	2·14″	104′	11·84″	137′	9·54″	170′	7·25″
3	9′	10·11″	42′	7·81″	75′	5·51″	108′	3·21″	141′	0·91″	173′	10·62″
4	13′	1·48″	45′	11·18″	78′	8·88″	111′	6·58″	144′	4·28″	177′	1·99″
5	16′	4·85″	49′	2·55″	82′	0·25″	114′	9·95″	147′	7·65″	180′	5·36″
6	19′	8·22″	52′	5·92″	85′	3·62″	118′	1·32″	150′	11·02″	183′	8·73″
7	22′	11·59″	55′	9·29″	88′	6·99″	121′	4·69″	154′	2·39″	187′	0·10″
8	26′	2·96″	59′	0·66″	91′	10·36″	124′	8·06″	157′	5·76″	190′	3·47″
9	29′	6·33″	62′	4·03″	95′	1·73″	127′	11·43″	160′	9·13″	193′	6·84″

DECIMALS OF AN INCH INTO FRACTIONS AND MILLIMETRES.

By means of this Table, decimals of an inch can be converted either into fractions—to the nearest 16th, 32nd, or 64th, as may be required—or into millimetres.

The Table can also be used for converting fractions into decimals, equivalents printed in heavy type being exact.

Decimal.	16ths.	32nds.	64ths.	Mm.	Decimal.	16ths.	32nds.	64ths.	Mm.	Decimal.	16ths.	32nds.	64ths.	Mm.
·01	0	0	1 —	0,3	·34	5 +	11 —	22 —	8,6	·67	11 —	21 +	43 —	17,0
·015625	0	0	**1**	0,4	·34375	5 +	**11**	22	8,7	·671875	11 —	21 +	**43**	17,1
·02	0	1 —	1 +	0,5	·35	6 —	11 +	22 +	8,9	·68	11 —	22 —	44 —	17,3
·03	0	1 —	2 —	0,8	·359375	6 —	11 +	**23**	9,1	·6875	**11**	22	44	17,5
·03125	0	**1**	2	0,8	·36	6 —	12 —	23 +	9,1	·69	11 +	22 +	44 +	17,5
·04	1 —	1 +	3 —	1,0	·37	6 —	12 —	24 —	9,4	·70	11 +	22 +	45 —	17,8
·046875	1 —	1 +	**3**	1,2	·375	**6**	12	24	9,5	·703125	11 +	22 +	**45**	17,9
·05	1 —	2 —	3 +	1,3	·38	6 +	12 +	24 +	9,7	·71	11 +	23 —	45 +	18,0
·06	1 —	2 —	4 —	1,5	·39	6 +	12 +	25 —	9,9	·71875	11 +	**23**	46	18,3
·0625	**1**	2	4	1,6	·390625	6 +	12 +	**25**	9,9	·72	12 —	23 +	46 +	18,3
·07	1 +	2 +	4 +	1,8	·40	6 +	13 —	26 —	10,2	·73	12 —	23 +	47 —	18,5
·078125	1 +	2 +	**5**	2,0	·40625	6 +	**13**	26	10,3	·734375	12 —	23 +	**47**	18,7
·08	1 +	3 —	5 +	2,0	·41	7 —	13 +	26 +	10,4	·74	12 —	24 —	47 +	18,8
·09	1 +	3 —	6 —	2,3	·42	7 —	13 +	27 —	10,7	·75	**12**	24	48	19,0
·09375	1 +	**3**	6	2,4	·421875	7 —	13 +	**27**	10,7	·76	12 +	24 +	49 —	19,3
·1	2 —	3 +	6 +	2,5	·43	7 —	14 —	28 —	10,9	·765625	12 +	24 +	**49**	19,4
·109375	2 —	3 +	**7**	2,8	·4375	**7**	14	28	11,1	·77	12 +	25 —	49 +	19,6
·11	2 —	4 —	7 +	2,8	·44	7 +	14 +	28 +	11,2	·78	12 +	25 —	50 —	19,8
·12	2 —	4 —	8 —	3,0	·45	7 +	14 +	29 —	11,4	·78125	12 +	**25**	50	19,8
·125	**2**	4	8	3,2	·453125	7 +	14 +	**29**	11,5	·79	13 —	25 +	51 —	20,1
·13	2 +	4 +	8 +	3,3	·46	7 +	15 —	29 +	11,7	·796875	13 —	25 +	**51**	20,2
·14	2 +	4 +	9 —	3,6	·46875	7 +	**15**	30	11,9	·80	13 —	26 —	51 +	20,3
·140625	2 +	4 +	**9**	3,6	·47	8 —	15 +	30 +	11,9	·81	13 —	26 —	52 —	20,6
·15	2 +	5 —	10 —	3,8	·48	8 —	15 +	31 —	12,2	·8125	**13**	26	52	20,6
·15625	2 +	**5**	10	4,0	·484375	8 —	15 +	**31**	12,3	·82	13 +	26 +	52 +	20,8
·16	3 —	5 +	10 +	4,1	·49	8 —	16 —	31 +	12,4	·828125	13 +	26 +	**53**	21,0
·17	3 —	5 +	11 —	4,3	·5	**8**	16	32	12,7	·83	13 +	27 —	53 +	21,1
·171875	3 —	5 +	**11**	4,4	·51	8 +	16 +	33 —	13,0	·84	13 +	27 —	54 —	21,3
·18	3 —	6 —	12 —	4,6	·515625	8 +	16 +	**33**	13,1	·84375	13 +	**27**	54	21,4
·1875	**3**	6	12	4,8	·52	8 +	17 —	33 +	13,2	·85	14 —	27 +	54 +	21,6
·19	3 +	6 +	12 +	4,8	·53	8 +	17 —	34 —	13,5	·859375	14 —	27 +	**55**	21,8
·20	3 +	6 +	13 —	5,1	·53125	8 +	**17**	34	13,5	·86	14 —	28 —	55 +	21,8
·203125	3 +	6 +	**13**	5,2	·54	9 —	17 +	35 —	13,7	·87	14 —	28 —	56 —	22,1
·21	3 +	7 —	13 +	5,3	·546875	9 —	17 +	**35**	13,9	·875	**14**	28	56	22,2
·21875	3 +	**7**	14	5,6	·55	9 —	18 —	35 +	14,0	·88	14 +	28 +	56 +	22,4
·22	4 —	7 +	14 +	5,6	·56	9 —	18 —	36 —	14,2	·89	14 +	28 +	57 —	22,6
·23	4 —	7 +	15 —	5,8	·5625	**9**	18	36	14,3	·890625	14 +	28 +	**57**	22,6
·234375	4 —	7 +	**15**	6,0	·57	9 +	18 +	36 +	14,5	·90	14 +	29 —	58 —	22,9
·24	4 —	8 —	15 +	6,1	·578125	9 +	18 +	**37**	14,7	·90625	14 +	**29**	58	23,0
·25	**4**	8	16	6,3	·58	9 +	19 —	37 +	14,7	·91	15 —	29 +	58 +	23,1
·26	4 +	8 +	17 —	6,6	·59	9 +	19 —	38 —	15,0	·92	15 —	29 +	59 —	23,4
·265625	4 +	8 +	**17**	6,7	·59375	9 +	**19**	38	15,1	·921875	15 —	29 +	**59**	23,4
·27	4 +	9 —	17 +	6,9	·60	10 —	19 +	38 +	15,2	·93	15 —	30 —	60 —	23,6
·28	4 +	9 —	18 —	7,1	·609375	10 —	19 +	**39**	15,5	·9375	**15**	30	60	23,8
·28125	4 +	**9**	18	7,1	·61	10 —	20 —	39 +	15,5	·94	15 +	30 +	60 +	23,9
·29	5 —	9 +	19 —	7,4	·62	10 —	20 —	40 —	15,7	·95	15 +	30 +	61 —	24,1
·296875	5 —	9 +	**19**	7,5	·625	**10**	20	40	15,9	·953125	15 +	30 +	**61**	24,2
·30	5 —	10 —	19 +	7,6	·63	10 +	20 +	40 +	16,0	·96	15 +	31 —	61 +	24,4
·31	5 —	10 —	20 —	7,9	·64	10 +	20 +	41 —	16,3	·96875	15 +	**31**	62	24,6
·3125	**5**	10	20	7,9	·640625	10 +	20 +	**41**	16,3	·97	16 —	31 +	62 +	24,6
·32	5 +	10 +	20 +	8,1	·65	10 +	21 —	42 —	16,5	·98	16 —	31 +	63 —	24,9
·328125	5 +	10 +	**21**	8,3	·65625	10 +	**21**	42	16,7	·984375	16 —	31 +	**63**	25,0
·33	5 +	11 —	21 +	8,4	·66	11 —	21 +	42 +	16,8	·99	16 —	32 —	63 +	25,1

AREAS AND VOLUMES: BRITISH TO METRIC.

SQUARE INCHES TO SQUARE CENTIMETRES. Sq. inch = 6,451591 Cm.²

Inches²	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	0,6452	1,2903	1,9355	2,5806	3,2258	3,8710	4,5161	5,1613	5,8064
1	6,4516	7,0968	7,7419	8,3871	9,0322	9,6774	10,3225	10,9677	11,6129	12,2580
2	12,9032	13,5483	14,1935	14,8387	15,4838	16,1290	16,7741	17,4193	18,0645	18,7096
3	19,3548	19,9999	20,6451	21,2903	21,9354	22,5806	23,2257	23,8709	24,5160	25,1612
4	25,8064	26,4515	27,0967	27,7418	28,3870	29,0322	29,6773	30,3225	30,9676	31,6128
5	32,2580	32,9031	33,5483	34,1934	34,8386	35,4838	36,1289	36,7741	37,4192	38,0644
6	38,7095	39,3547	39,9999	40,6450	41,2902	41,9353	42,5805	43,2257	43,8708	44,5160
7	45,1611	45,8063	46,4515	47,0966	47,7418	48,3869	49,0321	49,6773	50,3224	50,9676
8	51,6127	52,2579	52,9030	53,5482	54,1934	54,8385	55,4837	56,1288	56,7740	57,4192
9	58,0643	58,7095	59,3546	59,9998	60,6450	61,2901	61,9353	62,5804	63,2256	63,8708

SQUARE FEET TO SQUARE CENTIMETRES. 1 Sq. foot = 929,03 Cm.²

Feet²	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	93	186	279	372	465	557	650	743	836
1	929	1022	1115	1208	1301	1394	1486	1579	1672	1765
2	1858	1951	2044	2137	2230	2323	2415	2508	2601	2694
3	2787	2880	2973	3066	3159	3252	3345	3437	3530	3623
4	3716	3809	3902	3995	4088	4181	4274	4366	4459	4552
5	4645	4738	4831	4924	5017	5110	5203	5295	5388	5481
6	5574	5667	5760	5853	5946	6039	6132	6225	6317	6410
7	6503	6596	6689	6782	6875	6968	7061	7154	7246	7339
8	7432	7525	7618	7711	7804	7897	7990	8083	8175	8268
9	8361	8454	8547	8640	8733	8826	8919	9012	9104	9197

CUBIC INCHES TO CUBIC CENTIMETRES. 1 Cu. inch = 16,3870 Cm.³

Inches³	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	1,639	3,277	4,916	6,555	8,194	9,832	11,471	13,110	14,748
1	16,387	18,026	19,664	21,303	22,942	24,581	26,219	27,858	29,497	31,135
2	32,774	34,413	36,051	37,690	39,329	40,968	42,606	44,245	45,884	47,522
3	49,161	50,800	52,438	54,077	55,716	57,355	58,993	60,632	62,271	63,909
4	65,548	67,187	68,825	70,464	72,103	73,742	75,380	77,019	78,658	80,296
5	81,935	83,574	85,212	86,851	88,490	90,129	91,767	93,406	95,045	96,683
6	98,322	99,961	101,599	103,238	104,877	106,516	108,154	109,793	111,432	113,070
7	114,709	116,348	117,986	119,625	121,264	122,903	124,541	126,180	127,819	129,457
8	131,096	132,735	134,373	136,012	137,651	139,290	140,928	142,567	144,206	145,844
9	147,483	149,122	150,760	152,399	154,038	155,677	157,315	158,954	160,593	162,231

CUBIC FEET TO CUBIC CENTIMETRES. 1 Cu. foot = 28316,78 Cm.³

Feet³	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	2832	5663	8495	11327	14158	16990	19822	22653	25485
1	28317	31148	33980	36812	39643	42475	45307	48139	50971	53802
2	56634	59465	62297	65129	67960	70792	73624	76455	79287	82119
3	84950	87782	90614	93445	96277	99109	101940	104772	107604	110435
4	113267	116099	118930	121762	124594	127426	130257	133089	135921	138752
5	141584	144416	147247	150079	152911	155742	158574	161406	164237	167069
6	169901	172732	175564	178396	181227	184059	186891	189722	192554	195386
7	198217	201049	203881	206712	209544	212376	215208	218039	220871	223703
8	226534	229366	232198	235029	237861	240693	243524	246356	249188	252019
9	254851	257683	260514	263346	266178	269009	271841	274673	277504	280336

AREAS AND VOLUMES: METRIC TO BRITISH.

SQUARE CENTIMETRES TO SQUARE INCHES. 1 Sq. Cm. = ·155001 Ins².

Cm.²	,0	,1	,2	,3	,4	,5	,6	,7	,8	,9
0	...	·01550	·03100	·04650	·06200	·07750	·09300	·10850	·12400	·13950
1	·15500	·17050	·18600	·20150	·21700	·23250	·24800	·26350	·27900	·29450
2	·31000	·32550	·34100	·35650	·37200	·38750	·40300	·41850	·43400	·44950
3	·46500	·48050	·49600	·51150	·52700	·54250	·55800	·57350	·58900	·60450
4	·62000	·63550	·65100	·66650	·68200	·69750	·71300	·72850	·74400	·75950
5	·77500	·79050	·80600	·82150	·83700	·85250	·86800	·88350	·89900	·91450
6	·93000	·94550	·96100	·97650	·99200	1·00750	1·02300	1·03850	1·05400	1·06950
7	1·08500	1·10050	1·11600	1·13150	1·14700	1·16250	1·17800	1·19350	1·20900	1·22450
8	1·24000	1·25550	1·27100	1·28650	1·30200	1·31750	1·33300	1·34850	1·36400	1·37950
9	1·39500	1·41050	1·42600	1·44150	1·45701	1·47251	1·48801	1·50351	1·51901	1·53451

SQUARE METRES TO SQUARE FEET. 1 Sq. metre = 10·763926 Ft.²

Metres²	,0	,1	,2	,3	,4	,5	,6	,7	,8	,9
0	...	1·076	2·153	3·229	4·306	5·382	6·458	7·535	8·611	9·688
1	10·764	11·840	12·917	13·993	15·069	16·146	17·222	18·299	19·375	20·451
2	21·528	22·604	23·681	24·757	25·833	26·910	27·986	29·063	30·139	31·215
3	32·292	33·368	34·445	35·521	36·597	37·674	38·750	39·827	40·903	41·979
4	43·056	44·132	45·208	46·285	47·361	48·438	49·514	50·590	51·667	52·743
5	53·820	54·896	55·972	57·049	58·125	59·202	60·278	61·354	62·431	63·507
6	64·584	65·660	66·736	67·813	68·889	69·966	71·042	72·118	73·195	74·271
7	75·347	76·424	77·500	78·577	79·653	80·729	81·806	82·882	83·957	85·035
8	86·111	87·188	88·264	89·341	90·417	91·493	92·570	93·646	94·723	95·799
9	96·875	97·952	99·028	100·105	101·181	102·257	103·334	104·410	105·486	106·563

CUBIC CENTIMETRES TO CUBIC INCHES. 1 Cu. Cm. = ·061024 Ins.³

Cm.³	,0	,1	,2	,3	,4	,5	,6	,7	,8	,9
0	...	·00610	·01220	·01831	·02441	·03051	·03661	·04272	·04882	·05492
1	·06102	·06713	·07323	·07933	·08543	·09154	·09764	·10374	·10984	·11595
2	·12205	·12815	·13425	·14035	·14646	·15256	·15866	·16476	·17087	·17697
3	·18307	·18917	·19528	·20138	·20748	·21358	·21969	·22579	·23189	·23799
4	·24410	·25020	·25630	·26240	·26851	·27461	·28071	·28681	·29291	·29902
5	·30512	·31122	·31732	·32343	·32953	·33563	·34173	·34784	·35394	·36004
6	·36614	·37225	·37835	·38445	·39055	·39666	·40276	·40886	·41496	·42106
7	·42717	·43327	·43937	·44547	·45158	·45768	·46378	·46988	·47599	·48209
8	·48819	·49429	·50040	·50650	·51260	·51870	·52481	·53091	·53701	·54311
9	·54921	·55532	·56142	·56752	·57362	·57973	·58583	·59193	·59803	·60414

CUBIC METRES TO CUBIC FEET. 1 Cu. metre = 35·3148 Ft.³

Metres³	,0	,1	,2	,3	,4	,5	,6	,7	,8	,9
0	...	3·531	7·063	10·594	14·126	17·657	21·189	24·720	28·252	31·783
1	35·315	38·846	42·378	45·909	49·441	52·972	56·504	60·035	63·567	67·098
2	70·630	74·161	77·693	81·224	84·756	88·287	91·818	95·350	98·881	102·413
3	105·944	109·476	113·007	116·539	120·070	123·602	127·133	130·665	134·196	137·728
4	141·259	144·791	148·322	151·854	155·385	158·917	162·448	165·980	169·511	173·043
5	176·574	180·105	183·637	187·168	190·700	194·231	197·763	201·294	204·826	208·357
6	211·889	215·420	218·952	222·483	226·015	229·546	233·078	236·609	240·141	243·672
7	247·204	250·735	254·267	257·798	261·330	264·861	268·392	271·924	275·455	278·987
8	282·518	286·050	289·581	293·113	296·644	300·176	303·707	307·239	310·770	314·302
9	317·833	321·365	324·896	328·428	331·959	335·491	339·022	342·554	346·085	349·617

POUNDS INTO KILOGRAMMES.

1 Lb. = 0,4535925 Kilos. For Conversion of Tons, Cwts., Qrs. to Kilos, see page 304.

Lb.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	0,045	0,091	0,136	0,181	0,227	0,272	0,318	0,363	0,408
1	0,454	0,499	0,544	0,590	0,635	0,680	0,726	0,771	0,816	0,862
2	0,907	0,953	0,998	1,043	1,089	1,134	1,179	1,225	1,270	1,315
3	1,361	1,406	1,451	1,497	1,542	1,588	1,633	1,678	1,724	1,769
4	1,814	1,860	1,905	1,950	1,996	2,041	2,087	2,132	2,177	2,223
5	2,268	2,313	2,359	2,404	2,449	2,495	2,540	2,585	2,631	2,676
6	2,722	2,767	2,812	2,858	2,903	2.948	2,994	3,039	3,084	3,130
7	3,175	3,221	3,266	3,311	3,357	3,402	3,447	3,493	3,538	3,583
8	3,629	3,674	3,719	3,765	3,810	3,856	3,901	3,946	3,992	4,037
9	4,082	4,128	4,173	4,218	4,264	4,309	4,354	4,400	4,445	4,491

POUNDS PER FOOT—INTO KILOGRAMMES PER METRE.

1 Lb. per Foot = 1,488166 Kilos. per Metre.

Lb. per Ft.	0	1	2	3	4	5	6	7	8	9
0	...	1,488	2,976	4,465	5,953	7,441	8,929	10,42	11,91	13,39
10	14,88	16,37	17,86	19,35	20,83	22,32	23,81	25,30	26,79	28,28
20	29,76	31,25	32,74	34,23	35,72	37,20	38,69	40,18	41,67	43,16
30	44,65	46,13	47,62	49,11	50,60	52,09	53,57	55,06	56,55	58,04
40	59,53	61,02	62,50	63,99	65,48	66,97	68,46	69,94	71,43	72,92
50	74,41	75,90	77,39	78,87	80,36	81,85	83,34	84,83	86,31	87,80
60	89,29	90,78	92,27	93,76	95,24	96,73	98,22	99,71	101,2	102,7
70	104,2	105,7	107,1	108,6	110,1	111,6	113,1	114,6	116,1	117,6
80	119,1	120,5	122,0	123,5	125,0	126,5	128,0	129,5	131,1	132,4
90	133,9	135,4	136,9	138,4	139,9	141,4	142,9	144,4	145,8	147,3

POUNDS PER SQUARE INCH—TO KILOGRAMMES PER SQUARE MILLIMETRE.

1000 Lb. per Ins.^{2} = 0,703071 Kilos per Mm.^{2}

(For conversion of Tons to Lb., see page 303.) (See also Table under "Tests," page 272.)

Lb. per sq. in.	0	100	200	300	400	500	600	700	800	900
0	...	0,07031	0,14061	0,21092	0,28123	0,35154	0,42184	0,49215	0,56246	0,63276
1000	0,70307	0,77338	0,84369	0,91399	0,98430	1,05461	1,12491	1,19522	1,26553	1,33583
2000	1,40614	1,47648	1,54676	1,61706	1,68737	1,75768	1,82798	1,89829	1,96860	2,03891
3000	2,10921	2,17952	2,24983	2,32013	2,39044	2,46075	2,53106	2,60136	2,67167	2,74198
4000	2,81228	2,88259	2,95290	3,02321	3,09351	3,16383	3,23413	3,30443	3,37474	3,44505
5000	3,51536	3,58566	3,65597	3,72628	3,79658	3,86689	3,93720	4,00750	4,07781	4,14812
6000	4,21843	4,28873	4,35904	4,42935	4,49965	4,56996	4,64027	4,71058	4,78088	4,85119
7000	4,92150	4,99180	5,06211	5,13242	5,20273	5,27303	5,34334	5,41365	5,48395	5,55426
8000	5,62457	5,69488	5,76518	5,83549	5,90580	5,97610	6,04641	6,11672	6,18702	6,25733
9000	6,32764	6,39795	6,46825	6,53856	6,60887	6,67917	6,74948	6,81979	6,89010	6,96040

KILOGRAMMES INTO POUNDS.

1 Kilo. = 2·20462 Lb.

Kilos.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	0·220	0·441	0·661	0·882	1·102	1·323	1·543	1·764	1·984
1	2·205	2·425	2·645	2·866	3·086	3·307	3·527	3·748	3·968	4·189
2	4·409	4·630	4·850	5·071	5·291	5·512	5·732	5·952	6·173	6·393
3	6·614	6·834	7·055	7·275	7·496	7·716	7·937	8·157	8·378	8·598
4	8·818	9·039	9·259	9·480	9·700	9·921	10·14	10·36	10·58	10·80
5	11·02	11·24	11·46	11·68	11·90	12·13	12·35	12·57	12·79	13·01
6	13·23	13·45	13·67	13·89	14·11	14·33	14·55	14·77	14·99	15·21
7	15·43	15·65	15·87	16·09	16·31	16·53	16·76	16·98	17·20	17·42
8	17·64	17·86	18·08	18·30	18·52	18·74	18·96	19·18	19·40	19·62
9	19·84	20·06	20·28	20·50	20·72	20·94	21·16	21·38	21·61	21·83

KILOGRAMMES PER METRE—INTO POUNDS PER FOOT.

1 Kilo. per Metre = ·671968 Lb. per Foot.

Kilos per Metre.	0	1	2	3	4	5	6	7	8	9
0	...	0·672	1·344	2·016	2·688	3·360	4·032	4·704	5·376	6·048
10	6·720	7·392	8·064	8·736	9·408	10·08	10·75	11·42	12·10	12·77
20	13·44	14·11	14·78	15·45	16·13	16·80	17·47	18·14	18·81	19·49
30	20·16	20·83	21·50	22·17	22·85	23·52	24·19	24·86	25·53	26·21
40	26·88	27·55	28·22	28·89	29·57	30·24	30·91	31·58	32·25	32·93
50	33·60	34·27	34·94	35·61	36·29	36·96	37·63	38·30	38·97	39·65
60	40·32	40·99	41·66	42·33	43·01	43·68	44·35	45·02	45·69	46·37
70	47·04	47·71	48·38	49·05	49·73	50·40	51·07	51·74	52·41	53·08
80	53·76	54·43	55·10	55·77	56·44	57·12	57·79	58·46	59·13	59·80
90	60·48	61·15	61·82	62·49	63·16	63·84	64·51	65·18	65·85	66·52

KILOGRAMMES PER SQUARE MILLIMETRE—TO POUNDS PER SQUARE INCH.

1 Kilo. per Mm.^{2} = 1422·332 Lb. per In.^{2}

(For conversion of Lb. to Tons, see page 303.) (See also Table under "Tests," page 272.)

Kilos per Mm.^{2}	,0	,1	,2	,3	,4	,5	,6	,7	,8	,9
0	...	142·2	284·5	426·7	568·9	711·2	853·4	995·6	1137·9	1280·1
1	1422·3	1564·6	1706·8	1849·0	1991·3	2133·5	2275·7	2418·0	2560·2	2702·4
2	2844·7	2986·9	3129·1	3271·4	3413·6	3555·8	3698·1	3840·3	3982·5	4124·8
3	4267·0	4409·2	4551·5	4693·7	4835·9	4978·2	5120·4	5262·6	5404·9	5547·1
4	5689·3	5831·6	5973·8	6116·0	6258·3	6400·5	6542·7	6685·0	6827·2	6969·4
5	7111·7	7253·9	7396·1	7538·4	7680·6	7822·8	7965·1	8107·3	8249·5	8391·8
6	8534·0	8676·2	8818·5	8960·7	9102·9	9245·2	9387·4	9529·6	9671·9	9814·1
7	9956·3	10098·6	10240·8	10383·0	10525·3	10667·5	10809·7	10952·0	11094·2	11236·4
8	11378·7	11520·9	11663·1	11805·4	11947·6	12089·8	12232·1	12374·3	12516·5	12658·8
9	12801·0	12943·2	13085·5	13227·7	13369·9	13512·2	13654·4	13796·6	13938·9	14081·1

DECIMALS OF A TON INTO CWT., QR., LB.

7 lb. = 0·003125 ton. 1 lb. = 0·000,446,43 ton. 0·001 ton = 2 ¼ lb. approx.

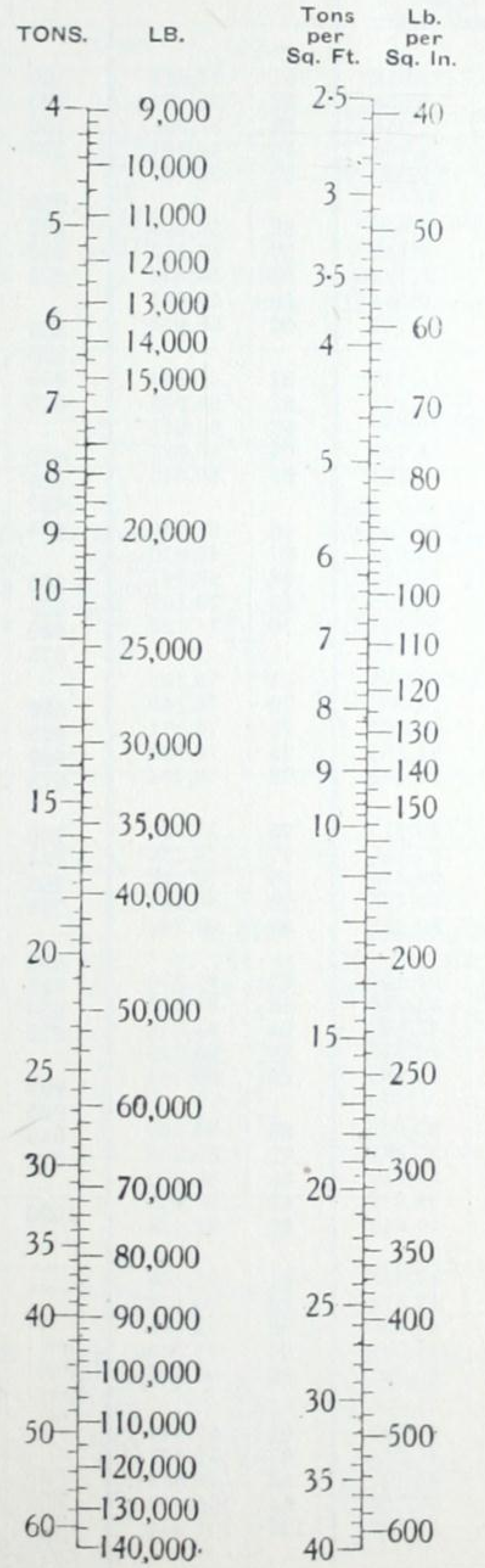
Decimal of 1 Ton.	Cwt.	Qr.	Lb.	Decimal of 1 Ton.	Cwt.	Qr.	Lb.	Decimal of 1 Ton.	Cwt.	Qr.	Lb.	Decimal of 1 Ton.	Cwt.	Qr.	Lb.	Decimal of 1 Ton.	Cwt.	Qr.	Lb.	Decimal of 1 Ton.	Cwt.	Qr.	Lb.
·003	0	0	7	·178	3	2	7	·353	7	0	7	·528	10	2	7	·703	14	0	7	·878	17	2	7
·006	0	0	14	·181	3	2	14	·356	7	0	14	·531	10	2	14	·706	14	0	14	·881	17	2	14
·009	0	0	21	·184	3	2	21	·359	7	0	21	·534	10	2	21	·709	14	0	21	·884	17	2	21
·012	0	1	0	·187	3	3	0	·362	7	1	0	·537	10	3	0	·712	14	1	0	·887	17	3	0
·016	0	1	7	·191	3	3	7	·366	7	1	7	·541	10	3	7	·716	14	1	7	·891	17	3	7
·019	0	1	14	·194	3	3	14	·369	7	1	14	·544	10	3	14	·719	14	1	14	·894	17	3	14
·022	0	1	21	·197	3	3	21	·372	7	1	21	·547	10	3	21	·722	14	1	21	·897	17	3	21
·025	0	2	0	·200	4	0	0	·375	7	2	0	·550	11	0	0	·725	14	2	0	·900	18	0	0
·028	0	2	7	·203	4	0	7	·378	7	2	7	·553	11	0	7	·728	14	2	7	·903	18	0	7
·031	0	2	14	·206	4	0	14	·381	7	2	14	·556	11	0	14	·731	14	2	14	·906	18	0	14
·034	0	2	21	·209	4	0	21	·384	7	2	21	·559	11	0	21	·734	14	2	21	·909	18	0	21
·037	0	3	0	·212	4	1	0	·387	7	3	0	·562	11	1	0	·737	14	3	0	·912	18	1	0
·041	0	3	7	·216	4	1	7	·391	7	3	7	·566	11	1	7	·741	14	3	7	·916	18	1	7
·044	0	3	14	·219	4	1	14	·394	7	3	14	·569	11	1	14	·744	14	3	14	·919	18	1	14
·047	0	3	21	·222	4	1	21	·397	7	3	21	·572	11	1	21	·747	14	3	21	·922	18	1	21
·050	1	0	0	·225	4	2	0	·400	8	0	0	·575	11	2	0	·750	15	0	0	·925	18	2	0
·053	1	0	7	·228	4	2	7	·403	8	0	7	·578	11	2	7	·753	15	0	7	·928	18	2	7
·056	1	0	14	·231	4	2	14	·406	8	0	14	·581	11	2	14	·756	15	0	14	·931	18	2	14
·059	1	0	21	·234	4	2	21	·409	8	0	21	·584	11	2	21	·759	15	0	21	·934	18	2	21
·062	1	1	0	·237	4	3	0	·412	8	1	0	·587	11	3	0	·762	15	1	0	·937	18	3	0
·066	1	1	7	·241	4	3	7	·416	8	1	7	·591	11	3	7	·766	15	1	7	·941	18	3	7
·069	1	1	14	·244	4	3	14	·419	8	1	14	·594	11	3	14	·769	15	1	14	·944	18	3	14
·072	1	1	21	·247	4	3	21	·422	8	1	21	·597	11	3	21	·772	15	1	21	·947	18	3	21
·075	1	2	0	·250	5	0	0	·425	8	2	0	·600	12	0	0	·775	15	2	0	·950	19	0	0
·078	1	2	7	·253	5	0	7	·428	8	2	7	·603	12	0	7	·778	15	2	7	·953	19	0	7
·081	1	2	14	·256	5	0	14	·431	8	2	14	·606	12	0	14	·781	15	2	14	·956	19	0	14
·084	1	2	21	·259	5	0	21	·434	8	2	21	·609	12	0	21	·784	15	2	21	·959	19	0	21
·087	1	3	0	·262	5	1	0	·437	8	3	0	·612	12	1	0	·787	15	3	0	·962	19	1	0
·091	1	3	7	·266	5	1	7	·441	8	3	7	·616	12	1	7	·791	15	3	7	·966	19	1	7
·094	1	3	14	·269	5	1	14	·444	8	3	14	·619	12	1	14	·794	15	3	14	·969	19	1	14
·097	1	3	21	·272	5	1	21	·447	8	3	21	·622	12	1	21	·797	15	3	21	·972	19	1	21
·100	2	0	0	·275	5	2	0	·450	9	0	0	·625	12	2	0	·800	16	0	0	·975	19	2	0
·103	2	0	7	·278	5	2	7	·453	9	0	7	·628	12	2	7	·803	16	0	7	·978	19	2	7
·106	2	0	14	·281	5	2	14	·456	9	0	14	·631	12	2	14	·806	16	0	14	·981	19	2	14
·109	2	0	21	·284	5	2	21	·459	9	0	21	·634	12	2	21	·809	16	0	21	·984	19	2	21
·112	2	1	0	·287	5	3	0	·462	9	1	0	·637	12	3	0	·812	16	1	0	·987	19	3	0
·116	2	1	7	·291	5	3	7	·466	9	1	7	·641	12	3	7	·816	16	1	7	·991	19	3	7
·119	2	1	14	·294	5	3	14	·469	9	1	14	·644	12	3	14	·819	16	1	14	·994	19	3	14
·122	2	1	21	·297	5	3	21	·472	9	1	21	·647	12	3	21	·822	16	1	21	·997	19	3	21
·125	2	2	0	·300	6	0	0	·475	9	2	0	·650	13	0	0	·825	16	2	0	...		...	
·128	2	2	7	·303	6	0	7	·478	9	2	7	·653	13	0	7	·828	16	2	7	...		...	
·131	2	2	14	·306	6	0	14	·481	9	2	14	·656	13	0	14	·831	16	2	14	...		...	
·134	2	2	21	·309	6	0	21	·484	9	2	21	·659	13	0	21	·834	16	2	21	...		...	
·137	2	3	0	·312	6	1	0	·487	9	3	0	·662	13	1	0	·837	16	3	0	...		...	
·141	2	3	7	·316	6	1	7	·491	9	3	7	·666	13	1	7	·841	16	3	7	...		...	
·144	2	3	14	·319	6	1	14	·494	9	3	14	·669	13	1	14	·844	16	3	14	...		...	
·147	2	3	21	·322	6	1	21	·497	9	3	21	·672	13	1	21	·847	16	3	21	...		...	
·150	3	0	0	·325	6	2	0	·500	10	0	0	·675	13	2	0	·850	17	0	0				
·153	3	0	7	·328	6	2	7	·503	10	0	7	·678	13	2	7	·853	17	0	7				
·156	3	0	14	·331	6	2	14	·506	10	0	14	·681	13	2	14	·856	17	0	14				
·159	3	0	21	·334	6	2	21	·509	10	0	21	·684	13	2	21	·859	17	0	21				
·162	3	1	0	·337	6	3	0	·512	10	1	0	·687	13	3	0	·862	17	1	0				
·166	3	1	7	·341	6	3	7	·516	10	1	7	·691	13	3	7	·866	17	1	7				
·169	3	1	14	·344	6	3	14	·519	10	1	14	·694	13	3	14	·869	17	1	14				
·172	3	1	21	·347	6	3	21	·522	10	1	21	·697	13	3	21	·872	17	1	21				
·175	3	2	0	·350	7	0	0	·525	10	2	0	·700	14	0	0	·875	17	2	0				

Lb.	Tons
1	·000
2	·001
3	·001
4	·002
5	·002
6	·003
7	·003

POUNDS INTO TONS.

Lb.	Tons. Cwts. Qrs. Lb.	Decimal of 1 Ton.
1,000	0 : 8 : 3 : 20	·4464
2,000	0 : 17 : 3 : 12	·8929
2,240	1 : – : – : –	1·0000
3,000	1 : 6 : 3 : 4	1·3393
4,000	1 : 15 : 2 : 24	1·7857
4,480	2 : – : – : –	2·0000
5,000	2 : 4 : 2 : 16	2·2321
6,000	2 : 13 : 2 : 8	2·6786
6,720	3 : – : – : –	3·0000
7,000	3 : 2 : 2 : 0	3·1250
8,000	3 : 11 : 1 : 20	3·5714
8,960	4 : – : – : –	4·0000
9,000	4 : 0 : 1 : 12	4·0179
10,000	4 : 9 : 1 : 4	4·4643
11,000	4 : 18 : 0 : 24	4·9107
11,200	5 : – : – : –	5·0000
12,000	5 : 7 : 0 : 16	5·3572
13,000	5 : 16 : 0 : 8	5·8036
13,440	6 : – : – : –	6·0000
14,000	6 : 5 : 0 : 0	6·2500
15,000	6 : 13 : 3 : 20	6·6964
15,680	7 : – : – : –	7·0000
16,000	7 : 2 : 3 : 12	7·1429
17,000	7 : 11 : 3 : 4	7·5893
17,920	8 : – : – : –	8·0000
18,000	8 : 0 : 2 : 24	8·0357
19,000	8 : 9 : 2 : 16	8·4822
20,000	8 : 18 : 2 : 8	8·9286
20,160	9 : – : – : –	9·0000
22,400	10 : – : – : –	10·0000
30,000	13 : 7 : 3 : 12	13·3929
40,000	17 : 17 : 0 : 16	17·8571
50,000	22 : 6 : 1 : 20	22·3214
60,000	26 : 15 : 2 : 24	26·7857
70,000	31 : 5 : 0 : 0	31·2500
80,000	35 : 14 : 1 : 4	35·7143
90,000	40 : 3 : 2 : 8	40·1786
100,000	44 : 12 : 3 : 12	44·6429

LOGARITHMIC SCALES.



TONS, CWTS., QRS., LB., INTO KILOGRAMMES.

1 lb. = 0,45359 kilo. 1 kilo. = 2·20462 lb. 1 ton = 1016,0475 kilos.

Tons.	Kilos.
1	1,016
2	2,032
3	3,048
4	4,064
5	5,080
6	6,096
7	7,112
8	8,128
9	9,144
10	10,160
11	11,177
12	12,193
13	13,209
14	14,225
15	15,241
16	16,257
17	17,273
18	18,289
19	19,305
20	20,321
21	21,337
22	22,353
23	23,369
24	24,385
25	25,401
26	26,417
27	27,433
28	28,449
29	29,465
30	30,481
31	31,497
32	32,514
33	33,530
34	34,546
35	35,562
36	36,578
37	37,594
38	38,610
39	39,626
40	40,642
41	41,658
42	42,674
43	43,690
44	44,706
45	45,722
46	46,738
47	47,754
48	48,770
49	49,786
50	50,802

Tons.	Kilos.
51	51,818
52	52,834
53	53,851
54	54,867
55	55,883
56	56,899
57	57,915
58	58,931
59	59,947
60	60,963
61	61,979
62	62,995
63	64,011
64	65,027
65	66,043
66	67,059
67	68,075
68	69,091
69	70,107
70	71,123
71	72,139
72	73,155
73	74,171
74	75,188
75	76,204
76	77,220
77	78,236
78	79,252
79	80,268
80	81,284
81	82,300
82	83,316
83	84,332
84	85,348
85	86,364
86	87,380
87	88,396
88	89,412
89	90,428
90	91,444
91	92,460
92	93,476
93	94,492
94	95,508
95	96,525
96	97,541
97	98,557
98	99,573
99	100,589
100	101,605

Tons.	Kilos.
100	101,605
125	127,006
150	152,407
175	177,809
200	203,210
225	228,611
250	254,012
275	279,414
300	304,814
325	330,215
350	355,616
375	381,018
400	406,419
425	431,820
450	457,221
475	482,623
500	508,024
525	533,425
550	558,826
575	584,228
600	609,629
625	635,030
650	660,431
675	685,833
700	711,233
725	736,634
750	762,035
775	787,437
800	812,838
825	838,239
850	863,640
875	889,042
900	914,443
925	939,844
950	965,245
975	990,647
1000	1016,048
...	...
...	...
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Cwts. Qrs.	Kilos.
...	...
0 1	13
0 2	25
0 3	38
1 0	51
1 1	64
1 2	76
1 3	89
2 0	102
2 1	114
2 2	127
2 3	140
3 0	152
3 1	165
3 2	178
3 3	191
4 0	203
4 1	216
4 2	229
4 3	241
5 0	254
5 1	267
5 2	279
5 3	292
6 0	305
6 1	318
6 2	330
6 3	343
7 0	356
7 1	368
7 2	381
7 3	394
8 0	406
8 1	419
8 2	432
8 3	445
9 0	457
9 1	470
9 2	483
9 3	495
10 0	508
10 1	521
10 2	533
10 3	546
11 0	559
11 1	572
11 2	584
11 3	597

Cwts. Qrs.	Kilos.
12 0	610
12 1	622
12 2	635
12 3	648
13 0	660
13 1	673
13 2	686
13 3	699
14 0	711
14 1	724
14 2	737
14 3	749
15 0	762
15 1	775
15 2	787
15 3	800
16 0	813
16 1	826
16 2	838
16 3	851
17 0	864
17 1	876
17 2	889
17 3	902
18 0	914
18 1	927
18 2	940
18 3	953
19 0	965
19 1	978
19 2	991
19 3	1003
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Lb.	Kilos.
1	0·454
2	0·907
3	1·361
4	1·814
5	2·268
6	2·722
7	3·175
8	3·629
9	4·082
10	4·536
11	4·989
12	5·443
13	5·897
14	6·350
15	6·804
16	7·257
17	7·711
18	8·165
19	8·618
20	9·072
21	9·525
22	9·979
23	10·433
24	10·886
25	11·340
26	11·793
27	12·247
28	12·701
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BRITISH WEIGHTS AND MEASURES.

WITH METRIC EQUIVALENTS.

LINEAR.

Miles.	Furlongs.	Chains.	Poles.	Yards.	Feet.	Links.	Inches.	Metric Equivalents.
1	8	80	320	1760	5280	8000	63,360	1609·34 metres
·125	1	10	40	220	660	1000	7920	201·168 ,,
·0125	·1	1	4	22	66	100	792	20·1168 ,,
...	·025	·25	1	5½	16½	25	198	5·0292 ,,
...	...	...	...	1	3	4·545	36	91·440 cm.
...	...	...	...	...	1	1·515	12	30·480 ,,
...	·001	·01	·04	·22	·66	1	7·92	20·117 ,,
...	...	...	...	...	...	...	1	25·4000 mm.

SQUARE.

Mile^2	Acres	Roods	Chains^2	Poles^2	Yards^2	Feet^2	Links^2	Inches^2	Metric Equivalents.
1	640	2560	6400	102,400	...	...	...	...	258·998 hectares
...	1	4	10	160	4840	43,560	100,000	...	4046·85 metres^2
...	...	1	2½	40	1210	10,890	25,000	...	1011·71 ,,
...	...	...	1	16	484	4356	10,000	...	404·685 ,,
...	...	...	...	1	30¼	272¼	625	39,204	25·293 ,,
...	...	...	...	...	1	9	...	1296	·83613 ,,
...	...	...	...	...	...	1	...	144	929·03 cm.^{2}
...	...	...	...	...	...	...	1	...	404·685 ,,
...	...	...	...	...	...	...	...	1	6·45159 ,,

CUBIC.

Yard^3	Quarters	Bushels	Feet^3	Pecks	Gallons	Quarts	Pints	Inches^3	Metric Equivalents.
1	...	...	27	...	...	...	...	46,656	·76455 metres^3
...	1	8	...	32	64	256	512	17,754·88	290·941 litres
...	·125	1	...	4	8	32	64	2219·360	36·3677 ,,
...	...	...	1	...	6·22882	...	...	1728	·02832 metres^3
...	...	·25	...	1	2	8	16	554·840	9·09192 litres
...	...	...	·16054	...	1	4	8	277·420	4·54596 ,,
...	...	...	...	...	...	1	2	69·355	1·13649 ,,
...	...	...	...	...	...	...	1	34·677	·56825 ,,
...	...	...	...	...	...	...	...	1	16·3870 cm.^{3}

WEIGHTS (AVOIRDUPOIS).

Tons.	Cwts.	Qrs.	Stones.	Lb.	Oz.	Drams.	Grains.	Metric Equivalents.
1	20	80	160	2240	35,840	573,440	...	1016·05 kilos.
·05	1	4	8	112	1792	28,672	784,000	50·8023 ,,
...	·25	1	2	28	448	7168	196,000	12·7006 ,,
...	·125	·5	1	14	224	3584	98,000	6·3503 ,,
...	...	...	...	1	16	256	7,000	453·59 grammes
...	...	...	...	...	1	16	437·5	28·3495 ,,
...	...	...	...	...	...	1	27·344	1·7719 ,,
...	...	...	...	..	...	...	1	·064799 ,,

WEIGHTS OF VARIOUS SUBSTANCES.

Lb. Per Cubic Foot.

See also weights of roofing materials, page 219.

Liquids.

Acid, Nitric (91%)	94
,, Sulphuric (87%)	112
Alcohol	49
Benzine	46
Gasoline	42
Mercury	849
Oils	58
Paraffin	56
Petrol	55
,, refined	50
Water, fresh	62
,, salt	64

Metals.

Aluminium	165
Brass	520
Bronze	510
Copper	550
Gold	1205
Gun-metal	540
Iron, cast	450
,, wrought	480
Lead	710
Nickel	530
Platinum	1342
Silver	655
Steel	490
Tin	460
White-metal	460
Zinc	440

Soils.

Chalk	170
Clay	135
Earth, loose	75
Gravel	110
Mud, dry	100
,, wet	120

Soils.—Continued.

Sand, dry, loose	100
,, wet	130
Shale	160

Stones, Masonry.

Brick, pressed	150
,, common	125
,, soft	100
Brickwork	112
Cement	90
Concrete	140
,, reinforced	150
,, coke breeze	90
Flint	160
Granite	170
Lime	60
,, mortar	105
Limestone, compressed	170
,, granular	125
,, loose broken	95
,, walls	165
Marble	170
Plaster of Paris	140
Rubble masonry	140
Sand, dry, loose	100
Sandstone	150
,, masonry	140
Slate	175

Timber.

Ash	50
Beech	50
Cedar	35
Cherry	42
Chestnut	41
Cork	15
Cypress	37
Ebony	76

Timber.—Continued.

Elm	35
,, Canadian	45
Greenheart	70
Hickory	53
Jarrah	63
Larch	34
Mahogany, Spanish	60
,, Honduras	35
Oak, English	60
,, American	53
Pine, White	25
,, Yellow	35
,, Red	40
,, Pitch	45
Plane	40
Poplar	25
Spruce	30
Sycamore	37
Teak	50
Walnut	40

Miscellaneous.

Anthracite, broken, loose	54
Asbestos	187
Asphalt	88
Coal, bituminous	85
,, broken, loose	50
Coke	45
,, loose	30
Flour	40
Glass, window	160
,, flint	190
Grain, Wheat	48
,, Barley	39
,, Oats	32
Hay & Straw, in bales	20
Ice	59
Salt	45
Sulphur	125
White Lead	197

WEIGHTS OF STORES.

For these estimates we are indebted to the Carnegie Steel Co. (Handbook, 23rd edition).
They represent Weights (lb.) per Cubic Foot of space occupied.

Building Materials.

	Lb.
Cement, Natural ...	59
,, Portland ...	73
Lime and Plaster ...	53

Groceries, Wines.

Beans, in bags	40
Canned Goods, in cases	58
Coffee, Roasted, in bags	33
,, Green, in bags ...	39
Dates, in cases	55
Figs, in cases	74
Flour, in barrels ...	40
Rice, in bags	58
Sal Soda, in barrels ...	46
Salt, in bags	70
Soap Powder, in cases ...	38
Starch, in barrels ...	25
Sugar, in barrels ...	43
,, in cases	51
Tea, in chests	25
Treacle, in barrels ...	48
Wines and Liquors, in barrels	38

Drugs, Paints, etc.

Alum, Pearl, in barrels	33
Blue Vitriol, in barrels	45
Glycerine, in cases ...	52
Linseed Oil, in barrels ...	36

Drugs, Paints, etc.—Cont'd.

	Lb.
Linseed Oil, in drums ...	45
Red Lead and Litharge, dry	132
Resin, in barrels ...	48
Shellac, Gum	38
Soda, Caustic, in iron drums	88
,, Silicate, in barrels	53
Sulphuric Acid	60
White Lead Paste, in cans ...	174
,, ,, dry ...	86

Hardware.

Hinges	64
Locks, in cases, packed	31
Sash Fasteners	48
Screws	101
Sheet Tin, in boxes ...	278
Wire, Insulated Copper, in coils ...	63
,, Galvanized Iron, in coils ...	74

Textiles, etc.

Cotton, in bales, compressed ...	18
,, Bleached Goods, in cases ...	28

Textiles, etc.—Continued.

	Lb.
Cotton, Flannel, in cases	12
,, Sheeting, in cases ...	23
,, Yarn, in cases ...	25
Hemp, Italian, compressed ...	22
,, Manila, compressed ...	30
Jute, compressed ...	41
Linen Damask, in cases	50
,, Goods, in cases ...	30
,, Towels, in cases ...	40
Tow, compressed ...	29
Wool, in bales—compressed ...	48
,, not compressed ...	13
,, Worsteds, in cases	27

Miscellaneous.

Glass and Chinaware, in crates	40
Hides and Leather, in bales	20
,, in bundles ...	37
Paper, Newspapers and Strawboards ...	35
,, Writing and Calendered ...	60
Rope, in coils	32

WEIGHTS OF BUILDING MATERIAL.

Values assumed by the London District Surveyors' Association.

Material.	Per Cub. Foot.	Material.	Per Cub. Foot.
	Cwts.		Cwts.
Stone	1½	Concrete, stone ballast aggregate	1¼
,, backed with brick	1¼	,, brick aggregate	1
Blue Brick in Cement or Mortar ...	1½	,, clinker ,, ...	¾
Glazed ,, ,, ...	1½	Reinforced Concrete, stone ballast aggregate	1⅜
Ordinary ,, ,, ,, ...	1	Constructional Timber	⅜

WEIGHTS OF SHEET METAL, ETC.

Lb. Per Foot Super.

Material.	Thickness. 1/16"	Thickness. 1"	Material.	Thickness. 1/16"	Thickness. 1"	Material.	Thickness. 1/16"	Thickness. 1"
Steel	2·55	40·8	Copper	2·86	45·8	Brass	2·74	43·9
Wrought Iron	2·50	40·0	Lead	3·71	59·4	Window Glass	0·81	13·0
Cast Iron ...	2·35	37·5	Zinc	2·34	37·5	Compact Slate	0·94	15·0

STEEL SHEET AND WIRE GAUGES.

Gauge No.	B.G. Thickness.		Weight per Sq. Foot.	I.S.W.G. Thickness.		Weight. Wire per 100 yds.	Weight. Sheets per sq. ft.	Gauge No.	B.G. Thickness.		Weight per Sq. Foot.	I.S.W.G. Thickness.		Weight. Wire per 100 yds.	Weight. Sheets per sq. ft.
	Ins.	Mm.	Lb.	Ins.	Mm.	Lb.	Lb.		Ins.	Mm.	- Lb.	Ins.	Mm.	Lb.	Lb.
1	·353	8,97	14·41	·300	7,62	72·0	12·24	**26**	·020	,498	·800	·018	,457	·259	·734
2	·315	7,99	12·84	·276	7,01	61·0	11·26	**27**	·017	,443	·712	·016	,417	·215	·669
3	·280	7,12	11·44	·252	6,40	50·8	10·28	**28**	·016	,397	·637	·015	,376	·175	·604
4	·250	6,35	10·20	·232	5,89	43·1	9·47	**29**	·0139	,353	·567	·0136	,345	·148	·555
5	·222	5,65	9·08	·212	5,38	36·0	8·65	**30**	·0123	,312	·502	·0124	,315	·123	·506
6	·198	5,03	8·08	·192	4,88	29·4	7·83	**31**	·0110	,279	·449	·0116	,295	...	·473
7	·176	4,48	7·20	·176	4,47	24·8	7·18	**32**	·0098	,249	·400	·0108	,274	...	·441
8	·157	3,99	6·41	·160	4,06	20·4	6·53	**33**	·0087	,221	·355	·0100	,254	...	·408
9	·140	3,55	5·70	·144	3,66	16·6	5·87	**34**	·0077	,196	·314	·0092	,234	...	·375
10	·125	3,17	5·10	·128	3,25	13·1	5·22	**35**	·0069	,175	·282	·0084	,213	...	·343
11	·111	2,83	4·54	·116	2,95	10·8	4·73	**36**	·0061	,155	·249	·0076	,193	...	·310
12	·099	2,52	4·04	·104	2,64	8·63	4·24	**37**	·0054	,137	·220	·0068	,173	...	·277
13	·088	2,24	3·60	·092	2,34	6·76	3·75	**38**	·0048	,122	·196	·0060	,152	...	·245
14	·078	1,99	3·20	·080	2,03	5·11	3·26	**39**	·0043	,109	·175	·0052	,132	...	·212
15	·070	1,77	2·85	·072	1,83	4·15	2·94	**40**	·0039	,098	·157	·0048	,122	...	·196
16	·062	1,59	2·55	·064	1,63	3·29	2·61	**41**	·0034	,087	·140	·0044	,112	...	·180
17	·056	1,41	2·27	·056	1,42	2·50	2·28	**42**	·0031	,078	·125	·0040	,102	...	·163
18	·049	1,26	2·02	·048	1,22	1·83	1·96	**43**	·0027	,069	·111	·0036	,091	...	·147
19	·044	1,12	1·79	·040	1,02	1·27	1·63	**44**	·0024	,061	·099	·0032	,081	...	·131
20	·039	,996	1·60	·036	,914	1·03	1·47	**45**	·0021	,055	·088	·0028	,071	...	·114
21	·035	,886	1·42	·032	,813	·819	1·31	**46**	·0019	,049	·078	·0024	,061	...	·098
22	·031	,794	1·27	·028	,711	·628	1·14	**47**	·0017	,043	069	·0020	,051	...	·082
23	·028	,707	1·13	·024	,610	·461	·979	**48**	·0015	,039	·062	·0016	,041	...	·065
24	·025	,629	1·01	·022	,559	·387	·898	**49**	·0013	,034	·055	·0012	,030	...	·049
25	·022	,560	·899	·020	,508	·320	·816	**50**	·0012	,030	·049	·0010	,025	...	·041

1. " B.G." (Birmingham Gauge) has long been the customary British commercial gauge for iron or steel sheets, whether black, tinned or galvanised; and also for hoops. It was legalized in July, 1914.

2. " I.S.W.G." refers to the Imperial Standard Wire Gauge, which was established in September, 1883 and is used for wire, electrodes, boiler tubes, etc.

3. It is useful to remember that 4-B.G. is 1/4", 10-B.G. 1/8", 16-B.G. 1/16", and that for every addition of 6 to the gauge number, the thickness is halved.

4. To obtain weights in iron, deduct 2%.

MATHEMATICAL TABLES.

* For Moments of Inertia of rectangles, see pages 254-255.

Math. tables.

Index, Code.

LOGARITHMS.

$\log \pi^2 = .9943$; $\log \pi = \cdot 4971$; $\log (1 \div \pi) = \bar{1}\cdot 5029$; $\log \sqrt{\pi} = \cdot 2486$.

	0	1	2	3	4	5	6	7	8	9	Mean Differences.								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	7	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
											Mean Differences.								

LOGARITHMS.—Continued.

Some useful Logarithms are given in "Weights and Measures," page 292.

	0	1	2	3	4	5	6	7	8	9	Mean Differences.								
											1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
											Mean Differences.								

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	Mean Differences.								
											1	2	3	4	5	6	7	8	9
·00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
·01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
·03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
·04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
·05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
·06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
·07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
·08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
·09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
·10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
·11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
·12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
·13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
·14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
·15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
·16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
·17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
·18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
·19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
·20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
·21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
·22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
·23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
·24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
·25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
·47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
·49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
Mean Differences.

ANTILOGARITHMS.—Continued.

	0	1	2	3	4	5	6	7	8	9	Mean Differences.								
											1	2	3	4	5	6	7	8	9
·50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
·51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
·52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
·53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
·54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
·55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
·56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
·57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
·58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
·59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
·60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
·61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
·62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
·63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
·64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
·65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
·66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
·67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
·68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
·69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
·70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
·71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
·72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
·73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
·74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
·75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
·76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
·77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
·78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
·79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
·80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
·81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
·82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
·83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
·84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
·85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
·86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
·87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
·88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
·89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
·90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
·91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
·92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
·93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
·94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
·95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
·96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
·97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
·98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
·99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
											Mean Differences.								

Index, Code.

NATURAL SINES.

For Logarithmic Sines, see following table.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences.				
											1′	2′	3′	4′	5′
0°	·0000	0017	0035	0052	0070	0087	0105	0122	0140	0157	3	6	9	12	15
1	·0175	0192	0209	0227	0244	0262	0279	0297	0314	0332	3	6	9	12	15
2	·0349	0366	0384	0401	0419	0436	0454	0471	0488	0506	3	6	9	12	15
3	·0523	0541	0558	0576	0593	0610	0628	0645	0663	0680	3	6	9	12	15
4	·0698	0715	0732	0750	0767	0785	0802	0819	0837	0854	3	6	9	12	14
5	·0872	0889	0906	0924	0941	0958	0976	0993	1011	1028	3	6	9	12	14
6	·1045	1063	1080	1097	1115	1132	1149	1167	1184	1201	3	6	9	12	14
7	·1219	1236	1253	1271	1288	1305	1323	1340	1357	1374	3	6	9	12	14
8	·1392	1409	1426	1444	1461	1478	1495	1513	1530	1547	3	6	9	12	14
9	·1564	1582	1599	1616	1633	1650	1668	1685	1702	1719	3	6	9	12	14
10	·1736	1754	1771	1788	1805	1822	1840	1857	1874	1891	3	6	9	11	14
11	·1908	1925	1942	1959	1977	1994	2011	2028	2045	2062	3	6	9	11	14
12	·2079	2096	2113	2130	2147	2164	2181	2198	2215	2233	3	6	9	11	14
13	·2250	2267	2284	2300	2317	2334	2351	2368	2385	2402	3	6	8	11	14
14	·2419	2436	2453	2470	2487	2504	2521	2538	2554	2571	3	6	8	11	14
15	·2588	2605	2622	2639	2656	2672	2689	2706	2723	2740	3	6	8	11	14
16	·2756	2773	2790	2807	2823	2840	2857	2874	2890	2907	3	6	8	11	14
17	·2924	2940	2957	2974	2990	3007	3024	3040	3057	3074	3	6	8	11	14
18	·3090	3107	3123	3140	3156	3173	3190	3206	3223	3239	3	6	8	11	14
19	·3256	3272	3289	3305	3322	3338	3355	3371	3387	3404	3	5	8	11	14
20	·3420	3437	3453	3469	3486	3502	3518	3535	3551	3567	3	5	8	11	14
21	·3584	3600	3616	3633	3649	3665	3681	3697	3714	3730	3	5	8	11	14
22	·3746	3762	3778	3795	3811	3827	3843	3859	3875	3891	3	5	8	11	14
23	·3907	3923	3939	3955	3971	3987	4003	4019	4035	4051	3	5	8	11	14
24	·4067	4083	4099	4115	4131	4147	4163	4179	4195	4210	3	5	8	11	13
25	·4226	4242	4258	4274	4289	4305	4321	4337	4352	4368	3	5	8	11	13
26	·4384	4399	4415	4431	4446	4462	4478	4493	4509	4524	3	5	8	10	13
27	·4540	4555	4571	4586	4602	4617	4633	4648	4664	4679	3	5	8	10	13
28	·4695	4710	4726	4741	4756	4772	4787	4802	4818	4833	3	5	8	10	13
29	·4848	4863	4879	4894	4909	4924	4939	4955	4970	4985	3	5	8	10	13
30	·5000	5015	5030	5045	5060	5075	5090	5105	5120	5135	3	5	8	10	13
31	·5150	5165	5180	5195	5210	5225	5240	5255	5270	5284	2	5	7	10	12
32	·5299	5314	5329	5344	5358	5373	5388	5402	5417	5432	2	5	7	10	12
33	·5446	5461	5476	5490	5505	5519	5534	5548	5563	5577	2	5	7	10	12
34	·5592	5606	5621	5635	5650	5664	5678	5693	5707	5721	2	5	7	10	12
35	·5736	5750	5764	5779	5793	5807	5821	5835	5850	5864	2	5	7	9	12
36	·5878	5892	5906	5920	5934	5948	5962	5976	5990	6004	2	5	7	9	12
37	·6018	6032	6046	6060	6074	6088	6101	6115	6129	6143	2	5	7	9	12
38	·6157	6170	6184	6198	6211	6225	6239	6252	6266	6280	2	5	7	9	11
39	·6293	6307	6320	6334	6347	6361	6374	6388	6401	6414	2	4	7	9	11
40	·6428	6441	6455	6468	6481	6494	6508	6521	6534	6547	2	4	7	9	11
41	·6561	6574	6587	6600	6613	6626	6639	6652	6665	6678	2	4	7	9	11
42	·6691	6704	6717	6730	6743	6756	6769	6782	6794	6807	2	4	6	9	11
43	·6820	6833	6845	6858	6871	6884	6896	6909	6921	6934	2	4	6	8	11
44	·6947	6959	6972	6984	6997	7009	7022	7034	7046	7059	2	4	6	8	10
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′
											Mean Differences.				

NATURAL SINES.—Continued.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
45°	·7071	7083	7096	7108	7120	7133	7145	7157	7169	7181	2	4	6	8	10
46	·7193	7206	7218	7230	7242	7254	7266	7278	7290	7302	2	4	6	8	10
47	·7314	7325	7337	7349	7361	7373	7385	7396	7408	7420	2	4	6	8	10
48	·7431	7443	7455	7466	7478	7490	7501	7513	7524	7536	2	4	6	8	10
49	·7547	7559	7570	7581	7593	7604	7615	7627	7638	7649	2	4	6	8	9
50	·7660	7672	7683	7694	7705	7716	7727	7738	7749	7760	2	4	6	7	9
51	·7771	7782	7793	7804	7815	7826	7837	7848	7859	7869	2	4	5	7	9
52	·7880	7891	7902	7912	7923	7934	7944	7955	7965	7976	2	4	5	7	9
53	·7986	7997	8007	8018	8028	8039	8049	8059	8070	8080	2	3	5	7	9
54	·8090	8100	8111	8121	8131	8141	8151	8161	8171	8181	2	3	5	7	8
55	·8192	8202	8211	8221	8231	8241	8251	8261	8271	8281	2	3	5	7	8
56	·8290	8300	8310	8320	8329	8339	8348	8358	8368	8377	2	3	5	6	8
57	·8387	8396	8406	8415	8425	8434	8443	8453	8462	8471	2	3	5	6	8
58	·8480	8490	8499	8508	8517	8526	8536	8545	8554	8563	2	3	5	6	8
59	·8572	8581	8590	8599	8607	8616	8625	8634	8643	8652	1	3	4	6	7
60	·8660	8669	8678	8686	8695	8704	8712	8721	8729	8738	1	3	4	6	7
61	·8746	8755	8763	8771	8780	8788	8796	8805	8813	8821	1	3	4	6	7
62	·8829	8838	8846	8854	8862	8870	8878	8886	8894	8902	1	3	4	5	7
63	·8910	8918	8926	8934	8942	8949	8957	8965	8973	8980	1	3	4	5	6
64	·8988	8996	9003	9011	9018	9026	9033	9041	9048	9056	1	3	4	5	6
65	·9063	9070	9078	9085	9092	9100	9107	9114	9121	9128	1	2	4	5	6
66	·9135	9143	9150	9157	9164	9171	9178	9184	9191	9198	1	2	3	5	6
67	·9205	9212	9219	9225	9232	9239	9245	9252	9259	9265	1	2	3	4	6
68	·9272	9278	9285	9291	9298	9304	9311	9317	9323	9330	1	2	3	4	5
69	·9336	9342	9348	9354	9361	9367	9373	9379	9385	9391	1	2	3	4	5
70	·9397	9403	9409	9415	9421	9426	9432	9438	9444	9449	1	2	3	4	5
71	·9455	9461	9466	9472	9478	9483	9489	9494	9500	9505	1	2	3	4	5
72	·9511	9516	9521	9527	9532	9537	9542	9548	9553	9558	1	2	3	3	4
73	·9563	9568	9573	9578	9583	9588	9593	9598	9603	9608	1	2	2	3	4
74	·9613	9617	9622	9627	9632	9636	9641	9646	9650	9655	1	2	2	3	4
75	·9659	9664	9668	9673	9677	9681	9686	9690	9694	9699	1	1	2	3	4
76	·9703	9707	9711	9715	9720	9724	9728	9732	9736	9740	1	1	2	3	3
77	·9744	9748	9751	9755	9759	9763	9767	9770	9774	9778	1	1	2	3	3
78	·9781	9785	9789	9792	9796	9799	9803	9806	9810	9813	1	1	2	2	3
79	·9816	9820	9823	9826	9829	9833	9836	9839	9842	9845	1	1	2	2	3
80	·9848	9851	9854	9857	9860	9863	9866	9869	9871	9874	0	1	1	2	2
81	·9877	9880	9882	9885	9888	9890	9893	9895	9898	9900	0	1	1	2	2
82	·9903	9905	9907	9910	9912	9914	9917	9919	9921	9923	0	1	1	2	2
83	·9925	9928	9930	9932	9934	9936	9938	9940	9942	9943	0	1	1	1	2
84	·9945	9947	9949	9951	9952	9954	9956	9957	9959	9960	0	1	1	1	2
85	·9962	9963	9965	9966	9968	9969	9971	9972	9973	9974	0	0	1	1	1
86	·9976	9977	9978	9979	9980	9981	9982	9983	9984	9985	0	0	1	1	1
87	·9986	9987	9988	9989	9990	9990	9991	9992	9993	9993	0	0	0	1	1
88	·9994	9995	9995	9996	9996	9997	9997	9997	9998	9998	0	0	0	0	0
89	·9998	9999	9999	9999	9999	1·000	1·000	1·000	1·000	1·000	0	0	0	0	0
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′ Mean Differences.

LOGARITHMIC SINES.

For Natural Sines, see previous table.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
0°	—∞	7·2419	5429	7190	8439	9408	$\overline{0200}$	$\overline{0870}$	$\overline{1450}$	$\overline{1961}$					
1	8·2419	2832	3210	3558	3880	4179	4459	4723	4971	5206					
2	8·5428	5640	5842	6035	6220	6397	6567	6731	6889	7041					
3	8·7188	7330	7468	7602	7731	7857	7979	8098	8213	8326					
4	8·8436	8543	8647	8749	8849	8946	9042	9135	9226	9315	16	32	48	64	80
5	8·9403	9489	9573	9655	9736	9816	9894	9970	$\overline{0046}$	$\overline{0120}$	13	26	39	52	65
6	9·0192	0264	0334	0403	0472	0539	0605	0670	0734	0797	11	22	33	44	55
7	9·0859	0920	0981	1040	1099	1157	1214	1271	1326	1381	10	19	29	38	48
8	9·1436	1489	1542	1594	1646	1697	1747	1797	1847	1895	8	17	25	34	42
9	9·1943	1991	2038	2085	2131	2176	2221	2266	2310	2353	8	15	23	30	38
10	9·2397	2439	2482	2524	2565	2606	2647	2687	2727	2767	7	14	20	27	34
11	9·2806	2845	2883	2921	2959	2997	3034	3070	3107	3143	6	12	19	25	31
12	9·3179	3214	3250	3284	3319	3353	3387	3421	3455	3488	6	11	17	23	28
13	9·3521	3554	3586	3618	3650	3682	3713	3745	3775	3806	5	11	16	21	26
14	9·3837	3867	3897	3927	3957	3986	4015	4044	4073	4102	5	10	15	20	24
15	9·4130	4158	4186	4214	4242	4269	4296	4323	4350	4377	5	9	14	18	23
16	9·4403	4430	4456	4482	4508	4533	4559	4584	4609	4634	4	9	13	17	21
17	9·4659	4684	4709	4733	4757	4781	4805	4829	4853	4876	4	8	12	16	20
18	9·4900	4923	4946	4969	4992	5015	5037	5060	5082	5104	4	8	11	15	19
19	9·5126	5148	5170	5192	5213	5235	5256	5278	5299	5320	4	7	11	14	18
20	9·5341	5361	5382	5402	5423	5443	5463	5484	5504	5523	3	7	10	14	17
21	9·5543	5563	5583	5602	5621	5641	5660	5679	5698	5717	3	6	10	13	16
22	9·5736	5754	5773	5792	5810	5828	5847	5865	5883	5901	3	6	9	12	15
23	9·5919	5937	5954	5972	5990	6007	6024	6042	6059	6076	3	6	9	12	15
24	9·6093	6110	6127	6144	6161	6177	6194	6210	6227	6243	3	6	8	11	14
25	9·6259	6276	6292	6308	6324	6340	6356	6371	6387	6403	3	5	8	11	13
26	9·6418	6434	6449	6465	6480	6495	6510	6526	6541	6556	3	5	8	10	13
27	9·6570	6585	6600	6615	6629	6644	6659	6673	6687	6702	2	5	7	10	12
28	9·6716	6730	6744	6759	6773	6787	6801	6814	6828	6842	2	5	7	9	12
29	9·6856	6869	6883	6896	6910	6923	6937	6950	6963	6977	2	4	7	9	11
30	9·6990	7003	7016	7029	7042	7055	7068	7080	7093	7106	2	4	6	9	11
31	9·7118	7131	7144	7156	7168	7181	7193	7205	7218	7230	2	4	6	8	10
32	9·7242	7254	7266	7278	7290	7302	7314	7326	7338	7349	2	4	6	8	10
33	9·7361	7373	7384	7396	7407	7419	7430	7442	7453	7464	2	4	6	8	10
34	9·7476	7487	7498	7509	7520	7531	7542	7553	7564	7575	2	4	6	7	9
35	9·7586	7597	7607	7618	7629	7640	7650	7661	7671	7682	2	4	5	7	9
36	9·7692	7703	7713	7723	7734	7744	7754	7764	7774	7785	2	3	5	7	9
37	9·7795	7805	7815	7825	7835	7844	7854	7864	7874	7884	2	3	5	7	8
38	9·7893	7903	7913	7922	7932	7941	7951	7960	7970	7979	2	3	5	6	8
39	9·7989	7998	8007	8017	8026	8035	8044	8053	8063	8072	2	3	5	6	8
40	9·8081	8090	8099	8108	8117	8125	8134	8143	8152	8161	1	3	4	6	7
41	9·8169	8178	8187	8195	8204	8213	8221	8230	8238	8247	1	3	4	6	7
42	9·8255	8264	8272	8280	8289	8297	8305	8313	8322	8330	1	3	4	6	7
43	9·8338	8346	8354	8362	8370	8378	8386	8394	8402	8410	1	3	4	5	7
44	9·8418	8426	8433	8441	8449	8457	8464	8472	8480	8487	1	3	4	5	6
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′ Mean Differences.	2′	3′	4′	5′

LOGARITHMIC SINES.—Continued.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
45°	9·8495	8502	8510	8517	8525	8532	8540	8547	8555	8562	1	2	4	5	6
46	9·8569	8577	8584	8591	8598	8606	8613	8620	8627	8634	1	2	4	5	6
47	9·8641	8648	8655	8662	8669	8676	8683	8690	8697	8704	1	2	3	5	6
48	9·8711	8718	8724	8731	8738	8745	8751	8758	8765	8771	1	2	3	4	6
49	9·8778	8784	8791	8797	8804	8810	8817	8823	8830	8836	1	2	3	4	5
50	9·8843	8849	8855	8862	8868	8874	8880	8887	8893	8899	1	2	3	4	5
51	9·8905	8911	8917	8923	8929	8935	8941	8947	8953	8959	1	2	3	4	5
52	9·8965	8971	8977	8983	8989	8995	9000	9006	9012	9018	1	2	3	4	5
53	9·9023	9029	9035	9041	9046	9052	9057	9063	9069	9074	1	2	3	4	5
54	9·9080	9085	9091	9096	9101	9107	9112	9118	9123	9128	1	2	3	4	5
55	9·9134	9139	9144	9149	9155	9160	9165	9170	9175	9181	1	2	3	3	4
56	9·9186	9191	9196	9201	9206	9211	9216	9221	9226	9231	1	2	3	3	4
57	9·9236	9241	9246	9251	9255	9260	9265	9270	9275	9279	1	2	2	3	4
58	9·9284	9289	9294	9298	9303	9308	9312	9317	9322	9326	1	2	2	3	4
59	9·9331	9335	9340	9344	9349	9353	9358	9362	9367	9371	1	1	2	3	4
60	9·9375	9380	9384	9388	9393	9397	9401	9406	9410	9414	1	1	2	3	4
61	9·9418	9422	9427	9431	9435	9439	9443	9447	9451	9455	1	1	2	3	3
62	9·9459	9463	9467	9471	9475	9479	9483	9487	9491	9495	1	1	2	3	3
63	9·9499	9503	9507	9510	9514	9518	9522	9525	9529	9533	1	1	2	3	3
64	9·9537	9540	9544	9548	9551	9555	9558	9562	9566	9569	1	1	2	2	3
65	9·9573	9576	9580	9583	9587	9590	9594	9597	9601	9604	1	1	2	2	3
66	9·9607	9611	9614	9617	9621	9624	9627	9631	9634	9637	1	1	2	2	3
67	9·9640	9643	9647	9650	9653	9656	9659	9662	9666	9669	1	1	2	2	3
68	9·9672	9675	9678	9681	9684	9687	9690	9693	9696	9699	0	1	1	2	2
69	9·9702	9704	9707	9710	9713	9716	9719	9722	9724	9727	0	1	1	2	2
70	9·9730	9733	9735	9738	9741	9743	9746	9749	9751	9754	0	1	1	2	2
71	9·9757	9759	9762	9764	9767	9770	9772	9775	9777	9780	0	1	1	2	2
72	9·9782	9785	9787	9789	9792	9794	9797	9799	9801	9804	0	1	1	2	2
73	9·9806	9808	9811	9813	9815	9817	9820	9822	9824	9826	0	1	1	2	2
74	9·9828	9831	9833	9835	9837	9839	9841	9843	9845	9847	0	1	1	1	2
75	9·9849	9851	9853	9855	9857	9859	9861	9863	9865	9867	0	1	1	1	2
76	9·9869	9871	9873	9875	9876	9878	9880	9882	9884	9885	0	1	1	1	2
77	9·9887	9889	9891	9892	9894	9896	9897	9899	9901	9902	0	1	1	1	1
78	9·9904	9906	9907	9909	9910	9912	9913	9915	9916	9918	0	1	1	1	1
79	9·9919	9921	9922	9924	9925	9927	9928	9929	9931	9932	0	0	1	1	1
80	9·9934	9935	9936	9937	9939	9940	9941	9943	9944	9945	0	0	1	1	1
81	9·9946	9947	9949	9950	9951	9952	9953	9954	9955	9956	0	0	1	1	1
82	9·9958	9959	9960	9961	9962	9963	9964	9965	9966	9967	0	0	1	1	1
83	9·9968	9968	9969	9970	9971	9972	9973	9974	9975	9975	0	0	0	0	1
84	9·9976	9977	9978	9978	9979	9980	9981	9981	9982	9983	0	0	0	0	1
85	9·9983	9984	9985	9985	9986	9987	9987	9988	9988	9989	0	0	0	0	0
86	9·9989	9990	9990	9991	9991	9992	9992	9993	9993	9994	0	0	0	0	0
87	9·9994	9994	9995	9995	9996	9996	9996	9996	9997	9997	0	0	0	0	0
88	9·9997	9998	9998	9998	9998	9999	9999	9999	9999	9999	0	0	0	0	0
89	9·9999	9999	10·00	10·00	10·00	10·00	10·00	10·00	10·00	10·00	0	0	0	0	0
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′ Mean Differences.	2′	3′	4′	5′

NATURAL COSINES.

For Logarithmic Cosines, see following table.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
0°	1·000	1·000	1·000	1·000	1·000	1·000	·9999	9999	9999	9999	0	0	0	0	0
1	·9998	9998	9998	9997	9997	9997	9996	9996	9995	9995	0	0	0	0	0
2	·9994	9993	9993	9992	9991	9990	9990	9989	9988	9987	0	0	0	1	1
3	·9986	9985	9984	9983	9982	9981	9980	9979	9978	9977	0	0	1	1	1
4	·9976	9974	9973	9972	9971	9969	9968	9966	9965	9963	0	0	1	1	1
5	·9962	9960	9959	9957	9956	9954	9952	9951	9949	9947	0	1	1	1	2
6	·9945	9943	9942	9940	9938	9936	9934	9932	9930	9928	0	1	1	1	2
7	·9925	9923	9921	9919	9917	9914	9912	9910	9907	9905	0	1	1	2	2
8	·9903	9900	9898	9895	9893	9890	9888	9885	9882	9880	0	1	1	2	2
9	·9877	9874	9871	9869	9866	9863	9860	9857	9854	9851	0	1	1	2	2
10	·9848	9845	9842	9839	9836	9833	9829	9826	9823	9820	1	1	2	2	3
11	·9816	9813	9810	9806	9803	9799	9796	9792	9789	9785	1	1	2	2	3
12	·9781	9778	9774	9770	9767	9763	9759	9755	9751	9748	1	1	2	3	3
13	·9744	9740	9736	9732	9728	9724	9720	9715	9711	9707	1	1	2	3	3
14	·9703	9699	9694	9690	9686	9681	9677	9673	9668	9664	1	1	2	3	4
15	·9659	9655	9650	9646	9641	9636	9632	9627	9622	9617	1	2	2	3	4
16	·9613	9608	9603	9598	9593	9588	9583	9578	9573	9568	1	2	2	3	4
17	·9563	9558	9553	9548	9542	9537	9532	9527	9521	9516	1	2	3	3	4
18	·9511	9505	9500	9494	9489	9483	9478	9472	9466	9461	1	2	3	4	5
19	·9455	9449	9444	9438	9432	9426	9421	9415	9409	9403	1	2	3	4	5
20	·9397	9391	9385	9379	9373	9367	9361	9354	9348	9342	1	2	3	4	5
21	·9336	9330	9323	9317	9311	9304	9298	9291	9285	9278	1	2	3	4	5
22	·9272	9265	9259	9252	9245	9239	9232	9225	9219	9212	1	2	3	4	6
23	·9205	9198	9191	9184	9178	9171	9164	9157	9150	9143	1	2	3	5	6
24	·9135	9128	9121	9114	9107	9100	9092	9085	9078	9070	1	2	4	5	6
25	·9063	9056	9048	9041	9033	9026	9018	9011	9003	8996	1	3	4	5	6
26	·8988	8980	8973	8965	8957	8949	8942	8934	8926	8918	1	3	4	5	6
27	·8910	8902	8894	8886	8878	8870	8862	8854	8846	8838	1	3	4	5	7
28	·8829	8821	8813	8805	8796	8788	8780	8771	8763	8755	1	3	4	6	7
29	·8746	8738	8729	8721	8712	8704	8695	8686	8678	8669	1	3	4	6	7
30	·8660	8652	8643	8634	8625	8616	8607	8599	8590	8581	1	3	4	6	7
31	·8572	8563	8554	8545	8536	8526	8517	8508	8499	8490	2	3	5	6	8
32	·8480	8471	8462	8453	8443	8434	8425	8415	8406	8396	2	3	5	6	8
33	·8387	8377	8368	8358	8348	8339	8329	8320	8310	8300	2	3	5	6	8
34	·8290	8281	8271	8261	8251	8241	8231	8221	8211	8202	2	3	5	7	8
35	·8192	8181	8171	8161	8151	8141	8131	8121	8111	8100	2	3	5	7	8
36	·8090	8080	8070	8059	8049	8039	8028	8018	8007	7997	2	3	5	7	9
37	·7986	7976	7965	7955	7944	7934	7923	7912	7902	7891	2	4	5	7	9
38	·7880	7869	7859	7848	7837	7826	7815	7804	7793	7782	2	4	5	7	9
39	·7771	7760	7749	7738	7727	7716	7705	7694	7683	7672	2	4	6	7	9
40	·7660	7649	7638	7627	7615	7604	7593	7581	7570	7559	2	4	6	8	9
41	·7547	7536	7524	7513	7501	7490	7478	7466	7455	7443	2	4	6	8	10
42	·7431	7420	7408	7396	7385	7373	7361	7349	7337	7325	2	4	6	8	10
43	·7314	7302	7290	7278	7266	7254	7242	7230	7218	7206	2	4	6	8	10
44	·7193	7181	7169	7157	7145	7133	7120	7108	7096	7083	2	4	6	8	10
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′ Mean Differences.

N.B.—Subtract Mean Differences.

NATURAL COSINES.—Continued.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences.				
											1′	2′	3′	4′	5′
45°	·7071	7059	7046	7034	7022	7009	6997	6984	6972	6959	2	4	6	8	10
46	·6947	6934	6921	6909	6896	6884	6871	6858	6845	6833	2	4	6	8	11
47	·6820	6807	6794	6782	6769	6756	6743	6730	6717	6704	2	4	6	9	11
48	·6691	6678	6665	6652	6639	6626	6613	6600	6587	6574	2	4	7	9	11
49	·6561	6547	6534	6521	6508	6494	6481	6468	6455	6441	2	4	7	9	11
50	·6428	6414	6401	6388	6374	6361	6347	6334	6320	6307	2	4	7	9	11
51	·6293	6280	6266	6252	6239	6225	6211	6198	6184	6170	2	5	7	9	11
52	·6157	6143	6129	6115	6101	6088	6074	6060	6046	6032	2	5	7	9	12
53	·6018	6004	5990	5976	5962	5948	5934	5920	5906	5892	2	5	7	9	12
54	·5878	5864	5850	5835	5821	5807	5793	5779	5764	5750	2	5	7	9	12
55	·5736	5721	5707	5693	5678	5664	5650	5635	5621	5606	2	5	7	10	12
56	·5592	5577	5563	5548	5534	5519	5505	5490	5476	5461	2	5	7	10	12
57	·5446	5432	5417	5402	5388	5373	5358	5344	5329	5314	2	5	7	10	12
58	·5299	5284	5270	5255	5240	5225	5210	5195	5180	5165	2	5	7	10	12
59	·5150	5135	5120	5105	5090	5075	5060	5045	5030	5015	3	5	8	10	13
60	·5000	4985	4970	4955	4939	4924	4909	4894	4879	4863	3	5	8	10	13
61	·4848	4833	4818	4802	4787	4772	4756	4741	4726	4710	3	5	8	10	13
62	·4695	4679	4664	4648	4633	4617	4602	4586	4571	4555	3	5	8	10	13
63	·4540	4524	4509	4493	4478	4462	4446	4431	4415	4399	3	5	8	10	13
64	·4384	4368	4352	4337	4321	4305	4289	4274	4258	4242	3	5	8	11	13
65	·4226	4210	4195	4179	4163	4147	4131	4115	4099	4083	3	5	8	11	13
66	·4067	4051	4035	4019	4003	3987	3971	3955	3939	3923	3	5	8	11	14
67	·3907	3891	3875	3859	3843	3827	3811	3795	3778	3762	3	5	8	11	14
68	·3746	3730	3714	3697	3681	3665	3649	3633	3616	3600	3	5	8	11	14
69	·3584	3567	3551	3535	3518	3502	3486	3469	3453	3437	3	5	8	11	14
70	·3420	3404	3387	3371	3355	3338	3322	3305	3289	3272	3	5	8	11	14
71	·3256	3239	3223	3206	3190	3173	3156	3140	3123	3107	3	6	8	11	14
72	·3090	3074	3057	3040	3024	3007	2990	2974	2957	2940	3	6	8	11	14
73	·2924	2907	2890	2874	2857	2840	2823	2807	2790	2773	3	6	8	11	14
74	·2756	2740	2723	2706	2689	2672	2656	2639	2622	2605	3	6	8	11	14
75	·2588	2571	2554	2538	2521	2504	2487	2470	2453	2436	3	6	8	11	14
76	·2419	2402	2385	2368	2351	2334	2317	2300	2284	2267	3	6	8	11	14
77	·2250	2233	2215	2198	2181	2164	2147	2130	2113	2096	3	6	9	11	14
78	·2079	2062	2045	2028	2011	1994	1977	1959	1942	1925	3	6	9	11	14
79	·1908	1891	1874	1857	1840	1822	1805	1788	1771	1754	3	6	9	11	14
80	·1736	1719	1702	1685	1668	1650	1633	1616	1599	1582	3	6	9	12	14
81	·1564	1547	1530	1513	1495	1478	1461	1444	1426	1409	3	6	9	12	14
82	·1392	1374	1357	1340	1323	1305	1288	1271	1253	1236	3	6	9	12	14
83	·1219	1201	1184	1167	1149	1132	1115	1097	1080	1063	3	6	9	12	14
84	·1045	1028	1011	0993	0976	0958	0941	0924	0906	0889	3	6	9	12	14
85	·0872	0854	0837	0819	0802	0785	0767	0750	0732	0715	3	6	9	12	14
86	·0698	0680	0663	0645	0628	0610	0593	0576	0558	0541	3	6	9	12	15
87	·0523	0506	0488	0471	0454	0436	0419	0401	0384	0366	3	6	9	12	15
88	·0349	0332	0314	0297	0279	0262	0244	0227	0209	0192	3	6	9	12	15
89	·0175	0157	0140	0122	0105	0087	0070	0052	0035	0017	3	6	9	12	15
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′
											Mean Differences.				

N.B.—Subtract Mean Differences.

Index, Code.

LOGARITHMIC COSINES.

For Natural Cosines, see previous table.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
0°	10·0000	0000	0000	0000	0000	0000	0000	0000	0000	9·9999	0	0	0	0	0
1	9·9999	9999	9999	9999	9999	9999	9998	9998	9998	9998	0	0	0	0	0
2	9·9997	9997	9997	9996	9996	9996	9996	9995	9995	9994	0	0	0	0	0
3	9·9994	9994	9993	9993	9992	9992	9991	9991	9990	9990	0	0	0	0	0
4	9·9989	9989	9988	9988	9987	9987	9986	9985	9985	9984	0	0	0	0	0
5	9·9983	9983	9982	9981	9981	9980	9979	9978	9978	9977	0	0	0	0	1
6	9·9976	9975	9975	9974	9973	9972	9971	9970	9969	9968	0	0	0	1	1
7	9·9968	9967	9966	9965	9964	9963	9962	9961	9960	9959	0	0	1	1	1
8	9·9958	9956	9955	9954	9953	9952	9951	9950	9949	9947	0	0	1	1	1
9	9·9946	9945	9944	9943	9941	9940	9939	9937	9936	9935	0	0	1	1	1
10	9·9934	9932	9931	9929	9928	9927	9925	9924	9922	9921	0	0	1	1	1
11	9·9919	9918	9916	9915	9913	9912	9910	9909	9907	9906	0	1	1	1	1
12	9·9904	9902	9901	9899	9897	9896	9894	9892	9891	9889	0	1	1	1	1
13	9·9887	9885	9884	9882	9880	9878	9876	9875	9873	9871	0	1	1	1	2
14	9·9869	9867	9865	9863	9861	9859	9857	9855	9853	9851	0	1	1	1	2
15	9·9849	9847	9845	9843	9841	9839	9837	9835	9833	9831	0	1	1	1	2
16	9·9828	9826	9824	9822	9820	9817	9815	9813	9811	9808	0	1	1	2	2
17	9·9806	9804	9801	9799	9797	9794	9792	9789	9787	9785	0	1	1	2	2
18	9·9782	9780	9777	9775	9772	9770	9767	9764	9762	9759	0	1	1	2	2
19	9·9757	9754	9751	9749	9746	9743	9741	9738	9735	9733	0	1	1	2	2
20	9·9730	9727	9724	9722	9719	9716	9713	9710	9707	9704	0	1	1	2	2
21	9·9702	9699	9696	9693	9690	9687	9684	9681	9678	9675	0	1	1	2	2
22	9·9672	9669	9666	9662	9659	9656	9653	9650	9647	9643	1	1	2	2	3
23	9·9640	9637	9634	9631	9627	9624	9621	9617	9614	9611	1	1	2	2	3
24	9·9607	9604	9601	9597	9594	9590	9587	9583	9580	9576	1	1	2	2	3
25	9·9573	9569	9566	9562	9558	9555	9551	9548	9544	9540	1	1	2	2	3
26	9·9537	9533	9529	9525	9522	9518	9514	9510	9507	9503	1	1	2	3	3
27	9·9499	9495	9491	9487	9483	9479	9475	9471	9467	9463	1	1	2	3	3
28	9·9459	9455	9451	9447	9443	9439	9435	9431	9427	9422	1	1	2	3	3
29	9·9418	9414	9410	9406	9401	9397	9393	9388	9384	9380	1	1	2	3	4
30	9·9375	9371	9367	9362	9358	9353	9349	9344	9340	9335	1	1	2	3	4
31	9·9331	9326	9322	9317	9312	9308	9303	9298	9294	9289	1	2	2	3	4
32	9·9284	9279	9275	9270	9265	9260	9255	9251	9246	9241	1	2	2	3	4
33	9·9236	9231	9226	9221	9216	9211	9206	9201	9196	9191	1	2	3	3	4
34	9·9186	9181	9175	9170	9165	9160	9155	9149	9144	9139	1	2	3	3	4
35	9·9134	9128	9123	9118	9112	9107	9101	9096	9091	9085	1	2	3	4	5
36	9·9080	9074	9069	9063	9057	9052	9046	9041	9035	9029	1	2	3	4	5
37	9·9023	9018	9012	9006	9000	8995	8989	8983	8977	8971	1	2	3	4	5
38	9·8965	8959	8953	8947	8941	8935	8929	8923	8917	8911	1	2	3	4	5
39	9·8905	8899	8893	8887	8880	8874	8868	8862	8855	8849	1	2	3	4	5
40	9·8843	8836	8830	8823	8817	8810	8804	8797	8791	8784	1	2	3	4	5
41	9·8778	8771	8765	8758	8751	8745	8738	8731	8724	8718	1	2	3	5	6
42	9·8711	8704	8697	8690	8683	8676	8669	8662	8655	8648	1	2	3	5	6
43	9·8641	8634	8627	8620	8613	8606	8598	8591	8584	8577	1	2	4	5	6
44	9·8569	8562	8555	8547	8540	8532	8525	8517	8510	8502	1	2	4	5	6
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′
											Mean Differences.				

N.B.—Subtract Mean Differences.

LOGARITHMIC COSINES.—Continued.

egrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
45°	9·8495	8487	8480	8472	8464	8457	8449	8441	8433	8426	1	3	4	5	6
46	9·8418	8410	8402	8394	8386	8378	8370	8362	8354	8346	1	3	4	5	7
47	9·8338	8330	8322	8313	8305	8297	8289	8280	8272	8264	1	3	4	6	7
48	9·8255	8247	8238	8230	8221	8213	8204	8195	8187	8178	1	3	4	6	7
49	9·8169	8161	8152	8143	8134	8125	8117	8108	8099	8090	1	3	4	6	7
50	9·8081	8072	8063	8053	8044	8035	8026	8017	8007	7998	2	3	5	6	8
51	9·7989	7979	7970	7960	7951	7941	7932	7922	7913	7903	2	3	5	6	8
52	9·7893	7884	7874	7864	7854	7844	7835	7825	7815	7805	2	3	5	7	8
53	9·7795	7785	7774	7764	7754	7744	7734	7723	7713	7703	2	3	5	7	9
54	9·7692	7682	7671	7661	7650	7640	7629	7618	7607	7597	2	4	5	7	9
55	9·7586	7575	7564	7553	7542	7531	7520	7509	7498	7487	2	4	6	7	9
56	9·7476	7464	7453	7442	7430	7419	7407	7396	7384	7373	2	4	6	8	10
57	9·7361	7349	7338	7326	7314	7302	7290	7278	7266	7254	2	4	6	8	10
58	9·7242	7230	7218	7205	7193	7181	7168	7156	7144	7131	2	4	6	8	10
59	9·7118	7106	7093	7080	7068	7055	7042	7029	7016	7003	2	4	6	9	11
60	9·6990	6977	6963	6950	6937	6923	6910	6896	6883	6869	2	4	7	9	11
61	9·6856	6842	6828	6814	6801	6787	6773	6759	6744	6730	2	5	7	9	12
62	9·6716	6702	6687	6673	6659	6644	6629	6615	6600	6585	2	5	7	10	12
63	9·6570	6556	6541	6526	6510	6495	6480	6465	6449	6434	3	5	8	10	13
64	9·6418	6403	6387	6371	6356	6340	6324	6308	6292	6276	3	5	8	11	13
65	9·6259	6243	6227	6210	6194	6177	6161	6144	6127	6110	3	6	8	11	14
66	9·6093	6076	6059	6042	6024	6007	5990	5972	5954	5937	3	6	9	12	15
67	9·5919	5901	5883	5865	5847	5828	5810	5792	5773	5754	3	6	9	12	15
68	9·5736	5717	5698	5679	5660	5641	5621	5602	5583	5563	3	6	10	13	16
69	9·5543	5523	5504	5484	5463	5443	5423	5402	5382	5361	3	7	10	14	17
70	9·5341	5320	5299	5278	5256	5235	5213	5192	5170	5148	4	7	11	14	18
71	9·5126	5104	5082	5060	5037	5015	4992	4969	4946	4923	4	8	11	15	19
72	9·4900	4876	4853	4829	4805	4781	4757	4733	4709	4684	4	8	12	16	20
73	9·4659	4634	4609	4584	4559	4533	4508	4482	4456	4430	4	9	13	17	21
74	9·4403	4377	4350	4323	4296	4269	4242	4214	4186	4158	5	9	14	18	23
75	9·4130	4102	4073	4044	4015	3986	3957	3927	3897	3867	5	10	15	20	24
76	9·3837	3806	3775	3745	3713	3682	3650	3618	3586	3554	5	11	16	21	26
77	9·3521	3488	3455	3421	3387	3353	3319	3284	3250	3214	6	11	17	23	28
78	9·3179	3143	3107	3070	3034	2997	2959	2921	2883	2845	6	12	19	25	31
79	9·2806	2767	2727	2687	2647	2606	2565	2524	2482	2439	7	14	20	27	34
80	9·2397	2353	2310	2266	2221	2176	2131	2085	2038	1991	8	15	23	30	38
81	9·1943	1895	1847	1797	1747	1697	1646	1594	1542	1489	8	17	25	34	42
82	9·1436	1381	1326	1271	1214	1157	1099	1040	0981	0920	10	19	29	38	48
83	9·0859	0797	0734	0670	0605	0539	0472	0403	0334	0264	11	22	33	44	55
84	9·0192	0120	0046	$\overline{9970}$	$\overline{9894}$	$\overline{9816}$	$\overline{9736}$	$\overline{9655}$	$\overline{9573}$	$\overline{9489}$	13	26	39	52	65
85	8·9403	9315	9226	9135	9042	8946	8849	8749	8647	8543	16	32	48	64	80
86	8·8436	8326	8213	8098	7979	7857	7731	7602	7468	7330					
87	8·7188	7041	6889	6731	6567	6397	6220	6035	5842	5640	*Mean* differences no longer sufficiently accurate.				
88	8·5428	5206	4971	4723	4459	4179	3880	3558	3210	2832					
89	8·2419	1961	1450	0870	0200	$\overline{9408}$	$\overline{8439}$	$\overline{7190}$	$\overline{5429}$	$\overline{2419}$					
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′ Mean Differences.

N.B.—Subtract Mean Differences.

Index, Code.

NATURAL TANGENTS.

For Logarithmic Tangents see following table.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
0°	·0000	0017	0035	0052	0070	0087	0105	0122	0140	0157	3	6	9	12	15
1	·0175	0192	0209	0227	0244	0262	0279	0297	0314	0332	3	6	9	12	15
2	·0349	0367	0384	0402	0419	0437	0454	0472	0489	0507	3	6	9	12	15
3	·0524	0542	0559	0577	0594	0612	0629	0647	0664	0682	3	6	9	12	15
4	·0699	0717	0734	0752	0769	0787	0805	0822	0840	0857	3	6	9	12	15
5	·0875	0892	0910	0928	0945	0963	0881	0998	1016	1033	3	6	9	12	15
6	·1051	1069	1086	1104	1122	1139	1157	1175	1192	1210	3	6	9	12	15
7	·1228	1246	1263	1281	1299	1317	1334	1352	1370	1388	3	6	9	12	15
8	·1405	1423	1441	1459	1477	1495	1512	1530	1548	1566	3	6	9	12	15
9	·1584	1602	1620	1638	1655	1673	1691	1709	1727	1745	3	6	9	12	15
10	·1763	1781	1799	1817	1835	1853	1871	1890	1908	1926	3	6	9	12	15
11	·1944	1962	1980	1998	2016	2035	2053	2071	2089	2107	3	6	9	12	15
12	·2126	2144	2162	2180	2199	2217	2235	2254	2272	2290	3	6	9	12	15
13	·2309	2327	2345	2364	2382	2401	2419	2438	2456	2475	3	6	9	12	15
14	·2493	2512	2530	2549	2568	2586	2605	2623	2642	2661	3	6	9	12	16
15	·2679	2698	2717	2736	2754	2773	2792	2811	2830	2849	3	6	9	13	16
16	·2867	2886	2905	2924	2943	2962	2981	3000	3019	3038	3	6	9	13	16
17	·3057	3076	3096	3115	3134	3153	3172	3191	3211	3230	3	6	10	13	16
18	·3249	3269	3288	3307	3327	3346	3365	3385	3404	3424	3	6	10	13	16
19	·3443	3463	3482	3502	3522	3541	3561	3581	3600	3620	3	7	10	13	16
20	·3640	3659	3679	3699	3719	3739	3759	3779	3799	3819	3	7	10	13	17
21	·3839	3859	3879	3899	3919	3939	3959	3979	4000	4020	3	7	10	13	17
22	·4040	4061	4081	4101	4122	4142	4163	4183	4204	4224	3	7	10	14	17
23	·4245	4265	4286	4307	4327	4348	4369	4390	4411	4431	3	7	10	14	17
24	·4452	4473	4494	4515	4536	4557	4578	4599	4621	4642	4	7	11	14	18
25	·4663	4684	4706	4727	4748	4770	4791	4813	4834	4856	4	7	11	14	18
26	·4877	4899	4921	4942	4964	4986	5008	5029	5051	5073	4	7	11	15	18
27	·5095	5117	5139	5161	5184	5206	5228	5250	5272	5295	4	7	11	15	18
28	·5317	5340	5362	5384	5407	5430	5452	5475	5498	5520	4	8	11	15	19
29	·5543	5566	5589	5612	5635	5658	5681	5704	5727	5750	4	8	12	15	19
30	·5774	5797	5820	5844	5867	5890	5914	5938	5961	5985	4	8	12	16	20
31	·6009	6032	6056	6080	6104	6128	6152	6176	6200	6224	4	8	12	16	20
32	·6249	6273	6297	6322	6346	6371	6395	6420	6445	6469	4	8	12	16	20
33	·6494	6519	6544	6569	6594	6619	6644	6669	6694	6720	4	8	13	17	21
34	·6745	6771	6796	6822	6847	6873	6899	6924	6950	6976	4	9	13	17	21
35	·7002	7028	7054	7080	7107	7133	7159	7186	7212	7239	4	9	13	18	22
36	·7265	7292	7319	7346	7373	7400	7427	7454	7481	7508	5	9	14	18	23
37	·7536	7563	7590	7618	7646	7673	7701	7729	7757	7785	5	9	14	18	23
38	·7813	7841	7869	7898	7926	7954	7983	8012	8040	8069	5	9	14	19	24
39	·8098	8127	8156	8185	8214	8243	8273	8302	8332	8361	5	10	15	20	24
40	·8391	8421	8451	8481	8511	8541	8571	8601	8632	8662	5	10	15	20	25
41	·8693	8724	8754	8785	8816	8847	8878	8910	8941	8972	5	10	16	21	26
42	·9004	9036	9067	9099	9131	9163	9195	9228	9260	9293	5	11	16	21	27
43	·9325	9358	9391	9424	9457	9490	9523	9556	9590	9623	6	11	17	22	28
44	·9657	9691	9725	9759	9793	9827	9861	9896	9930	9965	6	11	17	23	29
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′ Mean Differences.	2′	3′	4′	5′

NATURAL TANGENTS.—Continued.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
45°	1·0000	0035	0070	0105	0141	0176	0212	0247	0283	0319	6	12	18	24	30
46	1·0355	0392	0428	0464	0501	0538	0575	0612	0649	0686	6	12	18	25	31
47	1·0724	0761	0799	0837	0875	0913	0951	0990	1028	1067	6	13	19	25	32
48	1·1106	1145	1184	1224	1263	1303	1343	1383	1423	1463	7	13	20	27	33
49	1·1504	1544	1585	1626	1667	1708	1750	1792	1833	1875	7	14	21	28	34
50	1·1918	1960	2002	2045	2088	2131	2174	2218	2261	2305	7	14	22	29	36
51	1·2349	2393	2437	2482	2527	2572	2617	2662	2708	2753	8	15	23	30	38
52	1·2799	2846	2892	2938	2985	3032	3079	3127	3175	3222	8	16	24	31	39
53	1·3270	3319	3367	3416	3465	3514	3564	3613	3663	3713	8	16	25	33	41
54	1·3764	3814	3865	3916	3968	4019	4071	4124	4176	4229	9	17	26	34	43
55	1·4281	4335	4388	4442	4496	4550	4605	4659	4715	4770	9	18	27	36	45
56	1·4826	4882	4938	4994	5051	5108	5166	5224	5282	5340	10	19	29	38	48
57	1·5399	5458	5517	5577	5637	5697	5757	5818	5880	5941	10	20	30	40	50
58	1·6003	6066	6128	6191	6255	6319	6383	6447	6512	6577	11	21	32	43	53
59	1·6643	6709	6775	6842	6909	6977	7045	7113	7182	7251	11	23	34	45	56
60	1·7321	7391	7461	7532	7603	7675	7747	7820	7893	7966	12	24	36	48	60
61	1·8040	8115	8190	8265	8341	8418	8495	8572	8650	8728	13	26	38	51	64
62	1·8807	8887	8967	9047	9128	9210	9292	9375	9458	9542	14	27	41	55	68
63	1·9626	9711	9797	9883	9970	$\overline{0057}$	$\overline{0145}$	$\overline{0233}$	$\overline{0323}$	$\overline{0413}$	15	29	44	58	73
64	2·0503	0594	0686	0778	0872	0965	1060	1155	1251	1348	16	31	47	63	78
65	2·1445	1543	1642	1742	1842	1943	2045	2148	2251	2355	17	34	51	68	85
66	2·2460	2566	2673	2781	2889	2998	3109	3220	3332	3445	18	37	55	73	92
67	2·3559	3673	3789	3906	4023	4142	4262	4383	4504	4627	20	40	60	79	99
68	2·4751	4876	5002	5129	5257	5386	5517	5649	5782	5916	22	43	65	87	108
69	2·6051	6187	6325	6464	6605	6746	6889	7034	7179	7326	24	47	71	95	119
70	2·7475	7625	7776	7929	8083	8239	8397	8556	8716	8878	26	52	78	104	131
71	2·9042	9208	9375	9544	9714	9887	$\overline{0061}$	$\overline{0237}$	$\overline{0415}$	$\overline{0595}$	29	58	87	116	145
72	3·0777	0961	1146	1334	1524	1716	1910	2106	2305	2506	32	64	96	129	161
73	3·2709	2914	3122	3332	3544	3759	3977	4197	4420	4646	36	72	108	144	180
74	3·4874	5105	5339	5576	5816	6059	6305	6554	6806	7062	41	81	122	163	204
75	3·7321	7583	7848	8118	8391	8667	8947	9232	9520	9812	46	93	139	186	232
											1′	2′	3′	4′	5′
76	4·0108	0408	0713	1022	1335	1653	1976	2303	2635	2972					
77	4·3315	3662	4015	4374	4737	5107	5483	5864	6252	6646					
78	4·7046	7453	7867	8288	8716	9152	9594	$\overline{0045}$	$\overline{0504}$	$\overline{0970}$					
79	5·1446	1929	2422	2924	3435	3955	4486	5026	5578	6140					
80	5·6713	7297	7894	8502	9124	9758	$\overline{0405}$	$\overline{1066}$	$\overline{1742}$	$\overline{2432}$					
81	6·3138	3859	4596	5350	6122	6912	7720	8548	9395	$\overline{0264}$					
82	7·1154	2066	3002	3962	4947	5958	6996	8062	9158	$\overline{0285}$					
83	8·1443	2636	3863	5126	6427	7769	9152	$\overline{0579}$	$\overline{2052}$	$\overline{3572}$					
84	9·5144	9·677	9·845	10·02	10·20	10·39	10·58	10·78	10·99	11·20					
85	11·430	11·66	11·91	12·16	12·43	12·71	13·00	13·30	13·62	13·95					
86	14·301	14·67	15·06	15·46	15·89	16·35	16·83	17·34	17·89	18·46					
87	19·081	19·74	20·45	21·20	22·02	22·90	23·86	24·90	26·03	27·27					
88	28·636	30·14	31·82	33·69	35·80	38·19	40·92	44·07	47·74	52·08					
89	57·290	63·66	71·62	81·85	95·49	114·6	143·2	191·0	286·5	573·0					
	0′	**6′**	**12′**	**18′**	**24′**	**30′**	**36′**	**42′**	**48′**	**54′**					

Mean differences no longer sufficiently accurate.

Index, Code.

LOGARITHMIC TANGENTS.

For Natural Tangents, see previous table.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences.				
											1′	2′	3′	4′	5′
0°	—∞	7·2419	5429	7190	8439	9409	0200	0870	1450	1962					
1	8·2419	2833	3211	3559	3881	4181	4461	4725	4973	5208					
2	8·5431	5643	5845	6038	6223	6401	6571	6736	6894	7046					
3	8·7194	7337	7475	7609	7739	7865	7988	8107	8223	8336					
4	8·8446	8554	8659	8762	8862	8960	9056	9150	9241	9331	16	32	48	64	81
5	8·9420	9506	9591	9674	9756	9836	9915	9992	0068	0143	13	26	40	53	66
6	9·0216	0289	0360	0430	0499	0567	0633	0699	0764	0828	11	22	34	45	56
7	9·0891	0954	1015	1076	1135	1194	1252	1310	1367	1423	10	20	29	39	49
8	9·1478	1533	1587	1640	1693	1745	1797	1848	1898	1948	9	17	26	35	43
9	9·1997	2046	2094	2142	2189	2236	2282	2328	2374	2419	8	16	23	31	39
10	9·2463	2507	2551	2594	2637	2680	2722	2764	2805	2846	7	14	21	28	35
11	9·2887	2927	2967	3006	3046	3085	3123	3162	3200	3237	6	13	19	26	32
12	9·3275	3312	3349	3385	3422	3458	3493	3529	3564	3599	6	12	18	24	30
13	9·3634	3668	3702	3736	3770	3804	3837	3870	3903	3935	6	11	17	22	28
14	9·3968	4000	4032	4064	4095	4127	4158	4189	4220	4250	5	10	16	21	26
15	9·4281	4311	4341	4371	4400	4430	4459	4488	4517	4546	5	10	15	20	25
16	9·4575	4603	4632	4660	4688	4716	4744	4771	4799	4826	5	9	14	19	23
17	9·4853	4880	4907	4934	4961	4987	5014	5040	5066	5092	4	9	13	18	22
18	9·5118	5143	5169	5195	5220	5245	5270	5295	5320	5345	4	8	13	17	21
19	9·5370	5394	5419	5443	5467	5491	5516	5539	5563	5587	4	8	12	16	20
20	9·5611	5634	5658	5681	5704	5727	5750	5773	5796	5819	4	8	12	15	19
21	9·5842	5864	5887	5909	5932	5954	5976	5998	6020	6042	4	7	11	15	19
22	9·6064	6086	6108	6129	6151	6172	6194	6215	6236	6257	4	7	11	14	18
23	9·6279	6300	6321	6341	6362	6383	6404	6424	6445	6465	3	7	10	14	17
24	9·6486	6506	6527	6547	6567	6587	6607	6627	6647	6667	3	7	10	13	17
25	9·6687	6706	6726	6746	6765	6785	6804	6824	6843	6863	3	7	10	13	16
26	9·6882	6901	6920	6939	6958	6977	6996	7015	7034	7053	3	6	9	13	16
27	9·7072	7090	7109	7128	7146	7165	7183	7202	7220	7238	3	6	9	12	15
28	9·7257	7275	7293	7311	7330	7348	7366	7384	7402	7420	3	6	9	12	15
29	9·7438	7455	7473	7491	7509	7526	7544	7562	7579	7597	3	6	9	12	15
30	9·7614	7632	7649	7667	7684	7701	7719	7736	7753	7771	3	6	9	12	14
31	9·7788	7805	7822	7839	7856	7873	7890	7907	7924	7941	3	6	9	11	14
32	9·7958	7975	7992	8008	8025	8042	8059	8075	8092	8109	3	6	8	11	14
33	9·8125	8142	8158	8175	8191	8208	8224	8241	8257	8274	3	5	8	11	14
34	9·8290	8306	8323	8339	8355	8371	8388	8404	8420	8436	3	5	8	11	14
35	9·8452	8468	8484	8501	8517	8533	8549	8565	8581	8597	3	5	8	11	13
36	9·8613	8629	8644	8660	8676	8692	8708	8724	8740	8755	3	5	8	11	13
37	9·8771	8787	8803	8818	8834	8850	8865	8881	8897	8912	3	5	8	10	13
38	9·8928	8944	8959	8975	8990	9006	9022	9037	9053	9068	3	5	8	10	13
39	9·9084	9099	9115	9130	9146	9161	9176	9192	9207	9223	3	5	8	10	13
40	9·9238	9254	9269	9284	9300	9315	9330	9346	9361	9376	3	5	8	10	13
41	9·9392	9407	9422	9438	9453	9468	9483	9499	9514	9529	3	5	8	10	13
42	9·9544	9560	9575	9590	9605	9621	9636	9651	9666	9681	3	5	8	10	13
43	9·9697	9712	9727	9742	9757	9773	9788	9803	9818	9833	3	5	8	10	13
44	9·9848	9864	9879	9894	9909	9924	9939	9955	9970	9985	3	5	8	10	13
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′	2′	3′	4′	5′
											Mean Differences.				

LOGARITHMIC TANGENTS.—Continued.

Degrees	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	Mean Differences. 1′	2′	3′	4′	5′
45°	10·0000	0015	0030	0045	0061	0076	0091	0106	0121	0136	3	5	8	10	13
46	10·0152	0167	0182	0197	0212	0228	0243	0258	0273	0288	3	5	8	10	13
47	10·0303	0319	0334	0349	0364	0379	0395	0410	0425	0440	3	5	8	10	13
48	10·0456	0471	0486	0501	0517	0532	0547	0562	0578	0593	3	5	8	10	13
49	10·0608	0624	0639	0654	0670	0685	0700	0716	0731	0746	3	5	8	10	13
50	10·0762	0777	0793	0808	0824	0839	0854	0870	0885	0901	3	5	8	10	13
51	10·0916	0932	0947	0963	0978	0994	1010	1025	1041	1056	3	5	8	10	13
52	10·1072	1088	1103	1119	1135	1150	1166	1182	1197	1213	3	5	8	10	13
53	10·1229	1245	1260	1276	1292	1308	1324	1340	1356	1371	3	5	8	11	13
54	10·1387	1403	1419	1435	1451	1467	1483	1499	1516	1532	3	5	8	11	13
55	10·1548	1564	1580	1596	1612	1629	1645	1661	1677	1694	3	5	8	11	14
56	10·1710	1726	1743	1759	1776	1792	1809	1825	1842	1858	3	5	8	11	14
57	10·1875	1891	1908	1925	1941	1958	1975	1992	2008	2025	3	6	8	11	14
58	10·2042	2059	2076	2093	2110	2127	2144	2161	2178	2195	3	6	9	11	14
59	10·2212	2229	2247	2264	2281	2299	2316	2333	2351	2368	3	6	9	12	14
60	10·2386	2403	2421	2438	2456	2474	2491	2509	2527	2545	3	6	9	12	15
61	10·2562	2580	2598	2616	2634	2652	2670	2689	2707	2725	3	6	9	12	15
62	10·2743	2762	2780	2798	2817	2835	2854	2872	2891	2910	3	6	9	12	15
63	10·2928	2947	2966	2985	3004	3023	3042	3061	3080	3099	3	6	9	13	16
64	10·3118	3137	3157	3176	3196	3215	3235	3254	3274	3294	3	6	10	13	16
65	10·3313	3333	3353	3373	3393	3413	3433	3453	3473	3494	3	7	10	13	17
66	10·3514	3535	3555	3576	3596	3617	3638	3659	3679	3700	3	7	10	14	17
67	10·3721	3743	3764	3785	3806	3828	3849	3871	3892	3914	4	7	11	14	18
68	10·3936	3958	3980	4002	4024	4046	4068	4091	4113	4136	4	7	11	15	19
69	10·4158	4181	4204	4227	4250	4273	4296	4319	4342	4366	4	8	12	15	19
70	10·4389	4413	4437	4461	4484	4509	4533	4557	4581	4606	4	8	12	16	20
71	10·4630	4655	4680	4705	4730	4755	4780	4805	4831	4857	4	8	13	17	21
72	10·4882	4908	4934	4960	4986	5013	5039	5066	5093	5120	4	9	13	18	22
73	10·5147	5174	5201	5229	5256	5284	5312	5430	5368	5397	5	9	14	19	23
74	10·5425	5454	5483	5512	5541	5570	5600	5629	5659	5689	5	10	15	20	25
75	10·5719	5750	5780	5811	5842	5873	5905	5936	5968	6000	5	10	16	21	26
76	10·6032	6065	6097	6130	6163	6196	6230	6264	6298	6332	6	11	17	22	28
77	10·6366	6401	6436	6471	6507	6542	6578	6615	6651	6688	6	12	18	24	30
78	10·6725	6763	6800	6838	6877	6915	6954	6994	7033	7073	6	13	19	26	32
79	10·7113	7154	7195	7236	7278	7320	7363	7406	7449	7493	7	14	21	28	35
80	10·7537	7581	7626	7672	7718	7764	7811	7858	7906	7954	8	16	23	31	39
81	10·8003	8052	8102	8152	8203	8255	8307	8360	8413	8467	9	17	26	35	43
82	10·8522	8577	8633	8690	8748	8806	8865	8924	8985	9046	10	20	29	39	49
83	10·9109	9172	9236	9301	9367	9433	9501	9570	9640	9711	11	22	34	45	56
84	10·9784	9857	9932	0008	0085	0164	0244	0326	0409	0494	13	26	40	53	66
85	11·0580	0669	0759	0850	0944	1040	1138	1238	1341	1446	16	32	48	64	81
86	11·1554	1664	1777	1893	2012	2135	2261	2391	2525	2663	*Mean* differences no longer sufficiently accurate.				
87	11·2806	2954	3106	3264	3429	3599	3777	3962	4155	4357					
88	11·4569	4792	5027	5275	5539	5819	6119	6441	6789	7167					
89	11·7581	8038	8550	9130	9800	0591	1561	2810	4571	7581					
	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′	1′ Mean Differences.	2′	3′	4′	5′

FUNCTIONS OF NUMBERS.

1 TO 100.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
1	1	1	1·0000	1·0000	1000·000	51	2601	132651	7·1414	3·7084	19·6078
2	4	8	1·4142	1·2599	500·000	52	2704	140608	7·2111	3·7325	19·2308
3	9	27	1·7321	1·4422	333·333	53	2809	148877	7·2801	3·7563	18·8679
4	16	64	2·0000	1·5874	250·000	54	2916	157464	7·3485	3·7798	18·5185
5	25	125	2·2361	1·7100	200·000	55	3025	166375	7·4162	3·8030	18·1818
6	36	216	2·4495	1·8171	166·667	56	3136	175616	7·4833	3·8259	17·8571
7	49	343	2·6458	1·9129	142·857	57	3249	185193	7·5498	3·8485	17·5439
8	64	512	2·8284	2·0000	125·000	58	3364	195112	7·6158	3·8709	17·2414
9	81	729	3·0000	2·0801	111·111	59	3481	205379	7·6811	3·8930	16·9492
10	100	1000	3·1623	2·1544	100·000	60	3600	216000	7·7460	3·9149	16·6667
11	121	1331	3·3166	2·2240	90·9091	61	3721	226981	7·8102	3·9365	16·3934
12	144	1728	3·4641	2·2894	83·3333	62	3844	238328	7·8740	3·9579	16·1290
13	169	2197	3·6056	2·3513	76·9231	63	3969	250047	7·9373	3·9791	15·8730
14	196	2744	3·7417	2·4101	71·4286	64	4096	262144	8·0000	4·0000	15·6250
15	225	3375	3·8730	2·4662	66·6667	65	4225	274625	8·0623	4·0207	15·3846
16	256	4096	4·0000	2·5198	62·5000	66	4356	287496	8·1240	4·0412	15·1515
17	289	4913	4·1231	2·5713	58·8235	67	4489	300763	8·1854	4·0615	14·9254
18	324	5832	4·2426	2·6207	55·5556	68	4624	314432	8·2462	4·0817	14·7059
19	361	6859	4·3589	2·6684	52·6316	69	4761	328509	8·3066	4·1016	14·4928
20	400	8000	4·4721	2·7144	50·0000	70	4900	343000	8·3666	4·1213	14·2857
21	441	9261	4·5826	2·7589	47·6190	71	5041	357911	8·4261	4·1408	14·0845
22	484	10648	4·6904	2·8020	45·4545	72	5184	373248	8·4853	4·1602	13·8889
23	529	12167	4·7958	2·8439	43·4783	73	5329	389017	8·5440	4·1793	13·6986
24	576	13824	4·8990	2·8845	41·6667	74	5476	405224	8·6023	4·1983	13·5135
25	625	15625	5·0000	2·9240	40·0000	75	5625	421875	8·6603	4·2172	13·3333
26	676	17576	5·0990	2·9625	38·4615	76	5776	438976	8·7178	4·2358	13·1579
27	729	19683	5·1962	3·0000	37·0370	77	5929	456533	8·7750	4·2543	12·9870
28	784	21952	5·2915	3·0366	35·7143	78	6084	474552	8·8318	4·2727	12·8205
29	841	24389	5·3852	3·0723	34·4828	79	6241	493039	8·8882	4·2908	12·6582
30	900	27000	5·4772	3·1072	33·3333	80	6400	512000	8·9443	4·3089	12·5000
31	961	29791	5·5678	3·1414	32·2581	81	6561	531441	9·0000	4·3267	12·3457
32	1024	32768	5·6569	3·1748	31·2500	82	6724	551368	9·0554	4·3445	12·1951
33	1089	35937	5·7446	3·2075	30·3030	83	6889	571787	9·1104	4·3621	12·0482
34	1156	39304	5·8310	3·2396	29·4118	84	7056	592704	9·1652	4·3795	11·9048
35	1225	42875	5·9161	3·2711	28·5714	85	7225	614125	9·2195	4·3968	11·7647
36	1296	46656	6·0000	3·3019	27·7778	86	7396	636056	9·2736	4·4140	11·6279
37	1369	50653	6·0828	3·3322	27·0270	87	7569	658503	9·3274	4·4310	11·4943
38	1444	54872	6·1644	3·3620	26·3158	88	7744	681472	9·3808	4·4480	11·3636
39	1521	59319	6·2450	3·3912	25·6410	89	7921	704969	9·4340	4·4647	11·2360
40	1600	64000	6·3246	3·4200	25·0000	90	8100	729000	9·4868	4·4814	11·1111
41	1681	68921	6·4031	3·4482	24·3902	91	8281	753571	9·5394	4·4979	10·9890
42	1764	74088	6·4807	3·4760	23·8095	92	8464	778688	9·5917	4·5144	10·8696
43	1849	79507	6·5574	3·5034	23·2558	93	8649	804357	9·6437	4·5307	10·7527
44	1936	85184	6·6332	3·5303	22·7273	94	8836	830584	9·6954	4·5468	10·6383
45	2025	91125	6·7082	3·5569	22·2222	95	9025	857375	9·7468	4·5629	10·5263
46	2116	97336	6·7823	3·5830	21·7391	96	9216	884736	9·7980	4·5789	10·4167
47	2209	103823	6·8557	3·6088	21·2766	97	9409	912673	9·8489	4·5947	10·3093
48	2304	110592	6·9282	3·6342	20·8333	98	9604	941192	9·8995	4·6104	10·2041
49	2401	117649	7·0000	3·6593	20·4082	99	9801	970299	9·9499	4·6261	10·1010
50	2500	125000	7·0711	3·6840	20·0000	100	10000	1000000	10·0000	4·6416	10·0000

FUNCTIONS OF NUMBERS.

101 TO 200.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
101	10201	1030301	10·0499	4·6570	9·90099	151	22801	3442951	12·2882	5·3251	6·62252
102	10404	1061208	10·0995	4·6723	9·80392	152	23104	3511808	12·3288	5·3368	6·57895
103	10609	1092727	10·1489	4·6875	9·70874	153	23409	3581577	12·3693	5·3485	6·53595
104	10816	1124864	10·1980	4·7027	9·61538	154	23716	3652264	12·4097	5·3601	6·49351
105	11025	1157625	10·2470	4·7177	9·52381	155	24025	3723875	12·4499	5·3717	6·45161
106	11236	1191016	10·2956	4·7326	9·43396	156	24336	3796416	12·4900	5·3832	6·41026
107	11449	1225043	10·3441	4·7475	9·34579	157	24649	3869893	12·5300	5·3947	6·36943
108	11664	1259712	10·3923	4·7622	9·25926	158	24964	3944312	12·5698	5·4061	6·32911
109	11881	1295029	10·4403	4·7769	9·17431	159	25281	4019679	12·6095	5·4175	6·28931
110	12100	1331000	10·4881	4·7914	9·09091	160	25600	4096000	12·6491	5·4288	6·25000
111	12321	1367631	10·5357	4·8059	9·00901	161	25921	4173281	12·6886	5·4401	6·21118
112	12544	1404928	10·5830	4·8203	8·92857	162	26244	4251528	12·7279	5·4514	6·17284
113	12769	1442897	10·6301	4·8346	8·84956	163	26569	4330747	12·7671	5·4626	6·13497
114	12996	1481544	10·6771	4·8488	8·77193	164	26896	4410944	12·8062	5·4737	6·09756
115	13225	1520875	10·7238	4·8629	8·69565	165	27225	4492125	12·8452	5·4848	6·06061
116	13456	1560896	10·7703	4·8770	8·62069	166	27556	4574296	12·8841	5·4959	6·02410
117	13689	1601613	10·8167	4·8910	8·54701	167	27889	4657463	12·9228	5·5069	5·98802
118	13924	1643032	10·8628	4·9049	8·47458	168	28224	4741632	12·9615	5·5178	5·95238
119	14161	1685159	10·9087	4·9187	8·40336	169	28561	4826809	13·0000	5·5288	5·91716
120	14400	1728000	10·9545	4·9324	8·33333	170	28900	4913000	13·0384	5·5397	5·88235
121	14641	1771561	11·0000	4·9461	8·26446	171	29241	5000211	13·0767	5·5505	5·84795
122	14884	1815848	11·0454	4·9597	8·19672	172	29584	5088448	13·1149	5·5613	5·81395
123	15129	1860867	11·0905	4·9732	8·13008	173	29929	5177717	13·1529	5·5721	5·78035
124	15376	1906624	11·1355	4·9866	8·06452	174	30276	5268024	13·1909	5·5828	5·74713
125	15625	1953125	11·1803	5·0000	8·00000	175	30625	5359375	13·2288	5·5934	5·71429
126	15876	2000376	11·2250	5·0133	7·93651	176	30976	5451776	13·2665	5·6041	5·68182
127	16129	2048383	11·2694	5·0265	7·87402	177	31329	5545233	13·3041	5·6147	5·64972
128	16384	2097152	11·3137	5·0397	7·81250	178	31684	5639752	13·3417	5·6252	5·61798
129	16641	2146689	11·3578	5·0528	7·75194	179	32041	5735339	13·3791	5·6357	5·58659
130	16900	2197000	11·4018	5·0658	7·69231	180	32400	5832000	13·4164	5·6462	5·55556
131	17161	2248091	11·4455	5·0788	7·63359	181	32761	5929741	13·4536	5·6567	5·52486
132	17424	2299968	11·4891	5·0916	7·57576	182	33124	6028568	13·4907	5·6671	5·49451
133	17689	2352637	11·5326	5·1045	7·51880	183	33489	6128487	13·5277	5·6774	5·46448
134	17956	2406104	11·5758	5·1172	7·46269	184	33856	6229504	13·5647	5·6877	5·43478
135	18225	2460375	11·6190	5·1299	7·40741	185	34225	6331625	13·6015	5·6980	5·40541
136	18496	2515456	11·6619	5·1426	7·35294	186	34596	6434856	13·6382	5·7083	5·37634
137	18769	2571353	11·7047	5·1551	7·29927	187	34969	6539203	13·6748	5·7185	5·34759
138	19044	2628072	11·7473	5·1676	7·24638	188	35344	6644672	13·7113	5·7287	5·31915
139	19321	2685619	11·7898	5·1801	7·19424	189	35721	6751269	13·7477	5·7388	5·29101
140	19600	2744000	11·8322	5·1925	7·14286	190	36100	6859000	13·7840	5·7489	5·26316
141	19881	2803221	11·8743	5·2048	7·09220	191	36481	6967871	13·8203	5·7590	5·23560
142	20164	2863288	11·9164	5·2171	7·04225	192	36864	7077888	13·8564	5·7690	5·20833
143	20449	2924207	11·9583	5·2293	6·99301	193	37249	7189057	13·8924	5·7790	5·18135
144	20736	2985984	12·0000	5·2415	6·94444	194	37636	7301384	13·9284	5·7890	5·15464
145	21025	3048625	12·0416	5·2536	6·89655	195	38025	7414875	13·9642	5·7989	5·12821
146	21316	3112136	12·0830	5·2656	6·84932	196	38416	7529536	14·0000	5·8088	5·10204
147	21609	3176523	12·1244	5·2776	6·80272	197	38809	7645373	14·0357	5·8186	5·07614
148	21904	3241792	12·1655	5·2896	6·75676	198	39204	7762392	14·0712	5·8285	5·05051
149	22201	3307949	12·2066	5·3015	6·71141	199	39601	7880599	14·1067	5·8383	5·02513
150	22500	3375000	12·2474	5·3133	6·66667	200	40000	8000000	14·1421	5·8480	5·00000

Index, Code.

FUNCTIONS OF NUMBERS.

201 TO 300.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
201	40401	8120601	14·1774	5·8578	4·97512	**251**	63001	15813251	15·8430	6·3080	3·98406
202	40804	8242408	14·2127	5·8675	4·95050	**252**	63504	16003008	15·8745	6·3164	3·96825
203	41209	8365427	14·2478	5·8771	4·92611	**253**	64009	16194277	15·9060	6·3247	3·95257
204	41616	8489664	14·2829	5·8868	4·90196	**254**	64516	16387064	15·9374	6·3330	3·93701
205	42025	8615125	14·3178	5·8964	4·87805	**255**	65025	16581375	15·9687	6·3413	3·92157
206	42436	8741816	14·3527	5·9059	4·85437	**256**	65536	16777216	16·0000	6·3496	3·90625
207	42849	8869743	14·3875	5·9155	4·83092	**257**	66049	16974593	16·0312	6·3579	3·89105
208	43264	8998912	14·4222	5·9250	4·80769	**258**	66564	17173512	16·0624	6·3661	3·87597
209	43681	9129329	14·4568	5·9345	4·78469	**259**	67081	17373979	16·0935	6·3743	3·86100
210	44100	9261000	14·4914	5·9439	4·76190	**260**	67600	17576000	16·1245	6·3825	3·84615
211	44521	9393931	14·5258	5·9533	4·73934	**261**	68121	17779581	16·1555	6·3907	3·83142
212	44944	9528128	14·5602	5·9627	4·71698	**262**	68644	17984728	16·1864	6·3988	3·81679
213	45369	9663597	14·5945	5·9721	4·69484	**263**	69169	18191447	16·2173	6·4070	3·80228
214	45796	9800344	14·6287	5·9814	4·67290	**264**	69696	18399744	16·2481	6·4151	3·78788
215	46225	9938375	14·6629	5·9907	4·65116	**265**	70225	18609625	16·2788	6·4232	3·77358
216	46656	10077696	14·6969	6·0000	4·62963	**266**	70756	18821096	16·3095	6·4312	3·75940
217	47089	10218313	14·7309	6·0092	4·60829	**267**	71289	19034163	16·3401	6·4393	3·74532
218	47524	10360232	14·7648	6·0185	4·58716	**268**	71824	19248832	16·3707	6·4473	3·73134
219	47961	10503459	14·7986	6·0277	4·56621	**269**	72361	19465109	16·4012	6·4553	3·71747
220	48400	10648000	14·8324	6·0368	4·54545	**270**	72900	19683000	16·4317	6·4633	3·70370
221	48841	10793861	14·8661	6·0459	4·52489	**271**	73441	19902511	16·4621	6·4713	3·69004
222	49284	10941048	14·8997	6·0550	4·50450	**272**	73984	20123648	16·4924	6·4792	3·67647
223	49729	11089567	14·9332	6·0641	4·48431	**273**	74529	20346417	16·5227	6·4872	3·66300
224	50176	11239424	14·9666	6·0732	4·46429	**274**	75076	20570824	16·5529	6·4951	3·64964
225	50625	11390625	15·0000	6·0822	4·44444	**275**	75625	20796875	16·5831	6·5030	3·63636
226	51076	11543176	15·0333	6·0912	4·42478	**276**	76176	21024576	16·6132	6·5108	3·62319
227	51529	11697083	15·0665	6·1002	4·40529	**277**	76729	21253933	16·6433	6·5187	3·61011
228	51984	11852352	15·0997	6·1091	4·38596	**278**	77284	21484952	16·6733	6·5265	3·59712
229	52441	12008989	15·1327	6·1180	4·36681	**279**	77841	21717639	16·7033	6·5343	3·58423
230	52900	12167000	15·1658	6·1269	4·34783	**280**	78400	21952000	16·7332	6·5421	3·57143
231	53361	12326391	15·1987	6·1358	4·32900	**281**	78961	22188041	16·7631	6·5499	3·55872
232	53824	12487168	15·2315	6·1446	4·31034	**282**	79524	22425768	16·7929	6·5577	3·54610
233	54289	12649337	15·2643	6·1534	4·29185	**283**	80089	22665187	16·8226	6·5654	3·53357
234	54756	12812904	15·2971	6·1622	4·27350	**284**	80656	22906304	16·8523	6·5731	3·52113
235	55225	12977875	15·3297	6·1710	4·25532	**285**	81225	23149125	16·8819	6·5808	3·50877
236	55696	13144256	15·3623	6·1797	4·23729	**286**	81796	23393656	16·9115	6·5885	3·49650
237	56169	13312053	15·3948	6·1885	4·21941	**287**	82369	23639903	16·9411	6·5962	3·48432
238	56644	13481272	15·4272	6·1972	4·20168	**288**	82944	23887872	16·9706	6·6039	3·47222
239	57121	13651919	15·4596	6·2058	4·18410	**289**	83521	24137569	17·0000	6·6115	3·46021
240	57600	13824000	15·4919	6·2145	4·16667	**290**	84100	24389000	17·0294	6·6191	3·44828
241	58081	13997521	15·5242	6·2231	4·14938	**291**	84681	24642171	17·0587	6·6267	3·43643
242	58564	14172488	15·5563	6·2317	4·13223	**292**	85264	24897088	17·0880	6·6343	3·42466
243	59049	14348907	15·5885	6·2403	4·11523	**293**	85849	25153757	17·1172	6·6419	3·41297
244	59536	14526784	15·6205	6·2488	4·09836	**294**	86436	25412184	17·1464	6·6494	3·40136
245	60025	14706125	15·6525	6·2573	4·08163	**295**	87025	25672375	17·1756	6·6569	3·38983
246	60516	14886936	15·6844	6·2658	4·06504	**296**	87616	25934336	17·2047	6·6644	3·37838
247	61009	15069223	15·7162	6·2743	4·04858	**297**	88209	26198073	17·2337	6·6719	3·36700
248	61504	15252992	15·7480	6·2828	4·03226	**298**	88804	26463592	17·2627	6·6794	3·35570
249	62001	15438249	15·7797	6·2912	4·01606	**299**	89401	26730899	17·2916	6·6869	3·34448
250	62500	15625000	15·8114	6·2996	4·00000	**300**	90000	27000000	17·3205	6·6943	3·33333

FUNCTIONS OF NUMBERS.

301 TO 400.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
301	90601	27270901	17·3494	6·7018	3·32226	**351**	123201	43243551	18·7350	7·0540	2·84900
302	91204	27543608	17·3781	6·7092	3·31126	**352**	123904	43614208	18·7617	7·0607	2·84091
303	91809	27818127	17·4069	6·7166	3·30033	**353**	124609	43986977	18·7883	7·0674	2·83286
304	92416	28094464	17·4356	6·7240	3·28947	**354**	125316	44361864	18·8149	7·0740	2·82486
305	93025	28372625	17·4642	6·7313	3·27869	**355**	126025	44738875	18·8414	7·0807	2·81690
306	93636	28652616	17·4929	6·7387	3·26797	**356**	126736	45118016	18·8680	7·0873	2·80899
307	94249	28934443	17·5214	6·7460	3·25733	**357**	127449	45499293	18·8944	7·0940	2·80112
308	94864	29218112	17·5499	6·7533	3·24675	**358**	128164	45882712	18·9209	7·1006	2·79330
309	95481	29503629	17·5784	6·7606	3·23625	**359**	128881	46268279	18·9473	7·1072	2·78552
310	96100	29791000	17·6068	6·7679	3·22581	**360**	129600	46656000	18·9737	7·1138	2·77778
311	96721	30080231	17·6352	6·7752	3·21543	**361**	130321	47045881	19·0000	7·1204	2·77008
312	97344	30371328	17·6635	6·7824	3·20513	**362**	131044	47437928	19·0263	7·1269	2·76243
313	97969	30664297	17·6918	6·7897	3·19489	**363**	131769	47832147	19·0526	7·1335	2·75482
314	98596	30959144	17·7200	6·7969	3·18471	**364**	132496	48228544	19·0788	7·1400	2·74725
315	99225	31255875	17·7482	6·8041	3·17460	**365**	133225	48627125	19·1050	7·1466	2·73973
316	99856	31554496	17·7764	6·8113	3·16456	**366**	133956	49027896	19·1311	7·1531	2·73224
317	100489	31855013	17·8045	6·8185	3·15457	**367**	134689	49430863	19·1572	7·1596	2·72480
318	101124	32157432	17·8326	6·8256	3·14465	**368**	135424	49836032	19·1833	7·1661	2·71739
319	101761	32461759	17·8606	6·8328	3·13480	**369**	136161	50243409	19·2094	7·1726	2·71003
320	102400	32768000	17·8885	6·8399	3·12500	**370**	136900	50653000	19·2354	7·1791	2·70270
321	103041	33076161	17·9165	6·8470	3·11527	**371**	137641	51064811	19·2614	7·1855	2·69542
322	103684	33386248	17·9444	6·8541	3·10559	**372**	138384	51478848	19·2873	7·1920	2·68817
323	104329	33698267	17·9722	6·8612	3·09598	**373**	139129	51895117	19·3132	7·1984	2·68097
324	104976	34012224	18·0000	6·8683	3·08642	**374**	139876	52313624	19·3391	7·2048	2·67380
325	105625	34328125	18·0278	6·8753	3·07692	**375**	140625	52734375	19·3649	7·2112	2·66667
326	106276	34645976	18·0555	6·8824	3·06749	**376**	141376	53157376	19·3907	7·2177	2·65957
327	106929	34965783	18·0831	6·8894	3·05810	**377**	142129	53582633	19·4165	7·2240	2·65252
328	107584	35287552	18·1108	6·8964	3·04878	**378**	142884	54010152	19·4422	7·2304	2·64550
329	108241	35611289	18·1384	6·9034	3·03951	**379**	143641	54439939	19·4679	7·2368	2·63852
330	108900	35937000	18·1659	6·9104	3·03030	**380**	144400	54872000	19·4936	7·2432	2·63158
331	109561	36264691	18·1934	6·9174	3·02115	**381**	145161	55306341	19·5192	7·2495	2·62467
332	110224	36594368	18·2209	6·9244	3·01205	**382**	145924	55742968	19·5448	7·2558	2·61780
333	110889	36926037	18·2483	6·9313	3·00300	**383**	146689	56181887	19·5704	7·2622	2·61097
334	111556	37259704	18·2757	6·9382	2·99401	**384**	147456	56623104	19·5959	7·2685	2·60417
335	112225	37595375	18·3030	6·9451	2·98507	**385**	148225	57066625	19·6214	7·2748	2·59740
336	112896	37933056	18·3303	6·9521	2·97619	**386**	148996	57512456	19·6469	7·2811	2·59067
337	113569	38272753	18·3576	6·9589	2·96736	**387**	149769	57960603	19·6723	7·2874	2·58398
338	114244	38614472	18·3848	6·9658	2·95858	**388**	150544	58411072	19·6977	7·2936	2·57732
339	114921	38958219	18·4120	6·9727	2·94985	**389**	151321	58863869	19·7231	7·2999	2·57069
340	115600	39304000	18·4391	6·9795	2·94118	**390**	152100	59319000	19·7484	7·3061	2·56410
341	116281	39651821	18·4662	6·9864	2·93255	**391**	152881	59776471	19·7737	7·3124	2·55755
342	116964	40001688	18·4932	6·9932	2·92398	**392**	153664	60236288	19·7990	7·3186	2·55102
343	117649	40353607	18·5203	7·0000	2·91545	**393**	154449	60698457	19·8242	7·3248	2·54453
344	118336	40707584	18·5472	7·0068	2·90698	**394**	155236	61162984	19·8494	7·3310	2·53807
345	119025	41063625	18·5742	7·0136	2·89855	**395**	156025	61629875	19·8746	7·3372	2·53165
346	119716	41421736	18·6011	7·0203	2·89017	**396**	156816	62099136	19·8997	7·3434	2·52525
347	120409	41781923	18·6279	7·0271	2·88184	**397**	157609	62570773	19·9249	7·3496	2·51889
348	121104	42144192	18·6548	7·0338	2·87356	**398**	158404	63044792	19·9499	7·3558	2·51256
349	121801	42508549	18·6815	7·0406	2·86533	**399**	159201	63521199	19·9750	7·3619	2·50627
350	122500	42875000	18·7083	7·0473	2·85714	**400**	160000	64000000	20·0000	7·3681	2·50000

FUNCTIONS OF NUMBERS.

401 TO 500.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
401	160801	64481201	20·0250	7·3742	2·49377	**451**	203401	91733851	21·2368	7·6688	2·21730
402	161604	64964808	20·0499	7·3803	2·48756	**452**	204304	92345408	21·2603	7·6744	2·21239
403	162409	65450827	20·0749	7·3864	2·48139	**453**	205209	92959677	21·2838	7·6801	2·20751
404	163216	65939264	20·0998	7·3925	2·47525	**454**	206116	93576664	21·3073	7·6857	2·20264
405	164025	66430125	20·1246	7·3986	2·46914	**455**	207025	94196375	21·3307	7·6914	2·19780
406	164836	66923416	20·1494	7·4047	2·46305	**456**	207936	94818816	21·3542	7·6970	2·19298
407	165649	67419143	20·1742	7·4108	2·45700	**457**	208849	95443993	21·3776	7·7026	2·18818
408	166464	67917312	20·1990	7·4169	2·45098	**458**	209764	96071912	21·4009	7·7082	2·18341
409	167281	68417929	20·2237	7·4229	2·44499	**459**	210681	96702579	21·4243	7·7138	2·17865
410	168100	68921000	20·2485	7·4290	2·43902	**460**	211600	97336000	21·4476	7·7194	2·17391
411	168921	69426531	20·2731	7·4350	2·43309	**461**	212521	97972181	21·4709	7·7250	2·16920
412	169744	69934528	20·2978	7·4410	2·42718	**462**	213444	98611128	21·4942	7·7306	2·16450
413	170569	70444997	20·3224	7·4470	2·42131	**463**	214369	99252847	21·5174	7·7362	2·15983
414	171396	70957944	20·3470	7·4530	2·41546	**464**	215296	99897344	21·5407	7·7418	2·15517
415	172225	71473375	20·3715	7·4590	2·40964	**465**	216225	100544625	21·5639	7·7473	2·15054
416	173056	71991296	20·3961	7·4650	2·40385	**466**	217156	101194696	21·5870	7·7529	2·14592
417	173889	72511713	20·4206	7·4710	2·39808	**467**	218089	101847563	21·6102	7·7584	2·14133
418	174724	73034632	20·4450	7·4770	2·39234	**468**	219024	102503232	21·6333	7·7639	2·13675
419	175561	73560059	20·4695	7·4829	2·38664	**469**	219961	103161709	21·6564	7·7695	2·13220
420	176400	74088000	20·4939	7·4889	2·38095	**470**	220900	103823000	21·6795	7·7750	2·12766
421	177241	74618461	20·5183	7·4948	2·37530	**471**	221841	104487111	21·7025	7·7805	2·12314
422	178084	75151448	20·5426	7·5007	2·36967	**472**	222784	105154048	21·7256	7·7860	2·11864
423	178929	75686967	20·5670	7·5067	2·36407	**473**	223729	105823817	21·7486	7·7915	2·11417
424	179776	76225024	20·5913	7·5126	2·35849	**474**	224676	106496424	21·7715	7·7970	2·10971
425	180625	76765625	20·6155	7·5185	2·35294	**475**	225625	107171875	21·7945	7·8025	2·10526
426	181476	77308776	20·6398	7·5244	2·34742	**476**	226576	107850176	21·8174	7·8079	2·10084
427	182329	77854483	20·6640	7·5302	2·34192	**477**	227529	108531333	21·8403	7·8134	2·09644
428	183184	78402752	20·6882	7·5361	2·33645	**478**	228484	109215352	21·8632	7·8188	2·09205
429	184041	78953589	20·7123	7·5420	2·33100	**479**	229441	109902239	21·8861	7·8243	2·08768
430	184900	79507000	20·7364	7·5478	2·32558	**480**	230400	110592000	21·9089	7·8297	2·08333
431	185761	80062991	20·7605	7·5537	2·32019	**481**	231361	111284641	21·9317	7·8352	2·07900
432	186624	80621568	20·7846	7·5595	2·31482	**482**	232324	111980168	21·9545	7·8406	2·07469
433	187489	81182737	20·8087	7·5654	2·30947	**483**	233289	112678587	21·9773	7·8460	2·07039
434	188356	81746504	20·8327	7·5712	2·30415	**484**	234256	113379904	22·0000	7·8514	2·06612
435	189225	82312875	20·8567	7·5770	2·29885	**485**	235225	114084125	22·0227	7·8568	2·06186
436	190096	82881856	20·8806	7·5828	2·29358	**486**	236196	114791256	22·0454	7·8622	2·05761
437	190969	83453453	20·9045	7·5886	2·28833	**487**	237169	115501303	22·0681	7·8676	2·05339
438	191844	84027672	20·9284	7·5944	2·28311	**488**	238144	116214272	22·0907	7·8730	2·04918
439	192721	84604519	20·9523	7·6001	2·27790	**489**	239121	116930169	22·1133	7·8784	2·04499
440	193600	85184000	20·9762	7·6059	2·27273	**490**	240100	117649000	22·1359	7·8837	2·04082
441	194481	85766121	21·0000	7·6117	2·26757	**491**	241081	118370771	22·1585	7·8891	2·03666
442	195364	86350888	21·0238	7·6174	2·26244	**492**	242064	119095488	22·1811	7·8944	2·03252
443	196249	86938307	21·0476	7·6232	2·25734	**493**	243049	119823157	22·2036	7·8998	2·02840
444	197136	87528384	21·0713	7·6289	2·25225	**494**	244036	120553784	22·2261	7·9051	2·02429
445	198025	88121125	21·0950	7·6346	2·24719	**495**	245025	121287375	22·2486	7·9105	2·02020
446	198916	88716536	21·1187	7·6403	2·24215	**496**	246016	122023936	22·2711	7·9158	2·01613
447	199809	89314623	21·1424	7·6460	2·23714	**497**	247009	122763473	22·2935	7·9211	2·01207
448	200704	89915392	21·1660	7·6517	2·23214	**498**	248004	123505992	22·3159	7·9264	2·00803
449	201601	90518849	21·1896	7·6574	2·22717	**499**	249001	124251499	22·3383	7·9317	2·00401
450	202500	91125000	21·2132	7·6631	2·22222	**500**	250000	125000000	22·3607	7·9370	2·00000

FUNCTIONS OF NUMBERS.

501 TO 600.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
501	251001	125751501	22·3830	7·9423	1·99601	**551**	303601	167284151	23·4734	8·1982	1·81488
502	252004	126506008	22·4054	7·9476	1·99203	**552**	304704	168196608	23·4947	8·2031	1·81159
503	253009	127263527	22·4277	7·9528	1·98807	**553**	305809	169112377	23·5160	8·2081	1·80832
504	254016	128024064	22·4499	7·9581	1·98413	**554**	306916	170031464	23·5372	8·2130	1·80505
505	255025	128787625	22·4722	7·9634	1·98020	**555**	308025	170953875	23·5584	8·2180	1·80180
506	256036	129554216	22·4944	7·9686	1·97629	**556**	309136	171879616	23·5797	8·2229	1·79856
507	257049	130323843	22·5167	7·9739	1·97239	**557**	310249	172808693	23·6008	8·2278	1·79533
508	258064	131096512	22·5389	7·9791	1·96850	**558**	311364	173741112	23·6220	8·2327	1·79211
509	259081	131872229	22·5610	7·9843	1·96464	**559**	312481	174676879	23·6432	8·2377	1·78891
510	260100	132651000	22·5832	7·9896	1·96078	**560**	313600	175616000	23·6643	8·2426	1·78571
511	261121	133432831	22·6053	7·9948	1·95695	**561**	314721	176558481	23·6854	8·2475	1·78253
512	262144	134217728	22·6274	8·0000	1·95312	**562**	315844	177504328	23·7065	8·2524	1·77936
513	263169	135005697	22·6495	8·0052	1·94932	**563**	316969	178453547	23·7276	8·2573	1·77620
514	264196	135796744	22·6716	8·0104	1·94553	**564**	318096	179406144	23·7487	8·2621	1·77305
515	265225	136590875	22·6936	8·0156	1·94175	**565**	319225	180362125	23·7697	8·2670	1·76991
516	266256	137388096	22·7156	8·0208	1·93798	**566**	320356	181321496	23·7908	8·2719	1·76678
517	267289	138188413	22·7376	8·0260	1·93424	**567**	321489	182284263	23·8118	8·2768	1·76367
518	268324	138991832	22·7596	8·0311	1·93050	**568**	322624	183250432	23·8328	8·2816	1·76056
519	269361	139798359	22·7816	8·0363	1·92678	**569**	323761	184220009	23·8537	8·2865	1·75747
520	270400	140608000	22·8035	8·0415	1·92308	**570**	324900	185193000	23·8747	8·2913	1·75439
521	271441	141420761	22·8254	8·0466	1·91939	**571**	326041	186169411	23·8956	8·2962	1·75131
522	272484	142236648	22·8473	8·0517	1·91571	**572**	327184	187149248	23·9165	8·3010	1·74825
523	273529	143055667	22·8692	8·0569	1·91205	**573**	328329	188132517	23·9374	8·3059	1·74520
524	274576	143877824	22·8910	8·0620	1·90840	**574**	329476	189119224	23·9583	8·3107	1·74216
525	275625	144703125	22·9129	8·0671	1·90476	**575**	330625	190109375	23·9792	8·3155	1·73913
526	276676	145531576	22·9347	8·0723	1·90114	**576**	331776	191102976	24·0000	8·3203	1·73611
527	277729	146363183	22·9565	8·0774	1·89753	**577**	332929	192100033	24·0208	8·3251	1·73310
528	278784	147197952	22·9783	8·0825	1·89394	**578**	334084	193100552	24·0416	8·3300	1·73010
529	279841	148035889	23·0000	8·0876	1·89036	**579**	335241	194104539	24·0624	8·3348	1·72712
530	280900	148877000	23·0217	8·0927	1·88679	**580**	336400	195112000	24·0832	8·3396	1·72414
531	281961	149721291	23·0434	8·0978	1·88324	**581**	337561	196122941	24·1039	8·3443	1·72117
532	283024	150568768	23·0651	8·1028	1·87970	**582**	338724	197137368	24·1247	8·3491	1·71821
533	284089	151419437	23·0868	8·1079	1·87617	**583**	339889	198155287	24·1454	8·3539	1·71527
534	285156	152273304	23·1084	8·1130	1·87266	**584**	341056	199176704	24·1661	8·3587	1·71233
535	286225	153130375	23·1301	8·1180	1·86916	**585**	342225	200201625	24·1868	8·3634	1·70940
536	287296	153990656	23·1517	8·1231	1·86567	**586**	343396	201230056	24·2074	8·3682	1·70649
537	288369	154854153	23·1733	8·1281	1·86220	**587**	344569	202262003	24·2281	8·3730	1·70358
538	289444	155720872	23·1948	8·1332	1·85874	**588**	345744	203297472	24·2487	8·3777	1·70068
539	290521	156590819	23·2164	8·1382	1·85529	**589**	346921	204336469	24·2693	8·3825	1·69779
540	291600	157464000	23·2379	8·1433	1·85185	**590**	348100	205379000	24·2899	8·3872	1·69492
541	292681	158340421	23·2594	8·1483	1·84843	**591**	349281	206425071	24·3105	8·3919	1·69205
542	293764	159220088	23·2809	8·1533	1·84502	**592**	350464	207474688	24·3311	8·3967	1·68919
543	294849	160103007	23·3024	8·1583	1·84162	**593**	351649	208527857	24·3516	8·4014	1·68634
544	295936	160989184	23·3238	8·1633	1·83824	**594**	352836	209584584	24·3721	8·4061	1·68350
545	297025	161878625	23·3452	8·1683	1·83486	**595**	354025	210644875	24·3926	8·4108	1·68067
546	298116	162771336	23·3666	8·1733	1·83150	**596**	355216	211708736	24·4131	8·4155	1·67785
547	299209	163667323	23·3880	8·1783	1·82815	**597**	356409	212776173	24·4336	8·4202	1·67504
548	300304	164566592	23·4094	8·1833	1·82482	**598**	357604	213847192	24·4540	8·4249	1·67224
549	301401	165469149	23·4307	8·1882	1·82149	**599**	358801	214921799	24·4745	8·4296	1·66945
550	302500	166375000	23·4521	8·1932	1·81818	**600**	360000	216000000	24·4949	8·4343	1·66667

FUNCTIONS OF NUMBERS.

601 TO 700.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
601	361201	217081801	24·5153	8·4390	1·66389	**651**	423801	275894451	25·5147	8·6668	1·53610
602	362404	218167208	24·5357	8·4437	1·66113	**652**	425104	277167808	25·5343	8·6713	1·53374
603	363609	219256227	24·5561	8·4484	1·65837	**653**	426409	278445077	25·5539	8·6757	1·53139
604	364816	220348864	24·5764	8·4530	1·65563	**654**	427716	279726264	25·5734	8·6801	1·52905
605	366025	221445125	24·5967	8·4577	1·65289	**655**	429025	281011375	25·5930	8·6845	1·52672
606	367236	222545016	24·6171	8·4623	1·65017	**656**	430336	282300416	25·6125	8·6890	1·52439
607	368449	223648543	24·6374	8·4670	1·64745	**657**	431649	283593393	25·6320	8·6934	1·52207
608	369664	224755712	24·6577	8·4716	1·64474	**658**	432964	284890312	25·6515	8·6978	1·51976
609	370881	225866529	24·6779	8·4763	1·64204	**659**	434281	286191179	25·6710	8·7022	1·51745
610	372100	226981000	24·6982	8·4809	1·63934	**660**	435600	287496000	25·6905	8·7066	1·51515
611	373321	228099131	24·7184	8·4856	1·63666	**661**	436921	288804781	25·7099	8·7110	1·51286
612	374544	229220928	24·7386	8·4902	1·63399	**662**	438244	290117528	25·7294	8·7154	1·51057
613	375769	230346397	24·7588	8·4948	1·63132	**663**	439569	291434247	25·7488	8·7198	1·50830
614	376996	231475544	24·7790	8·4994	1·62866	**664**	440896	292754944	25·7682	8·7241	1·50602
615	378225	232608375	24·7992	8·5040	1·62602	**665**	442225	294079625	25·7876	8·7285	1·50376
616	379456	233744896	24·8193	8·5086	1·62338	**666**	443556	295408296	25·8070	8·7329	1·50150
617	380689	234885113	24·8395	8·5132	1·62075	**667**	444889	296740963	25·8263	8·7373	1·49925
618	381924	236029032	24·8596	8·5178	1·61812	**668**	446224	298077632	25·8457	8·7416	1·49701
619	383161	237176659	24·8797	8·5224	1·61551	**669**	447561	299418309	25·8650	8·7460	1·49477
620	384400	238328000	24·8998	8·5270	1·61290	**670**	448900	300763000	25·8844	8·7503	1·49254
621	385641	239483061	24·9199	8·5316	1·61031	**671**	450241	302111711	25·9037	8·7547	1·49031
622	386884	240641848	24·9399	8·5362	1·60772	**672**	451584	303464448	25·9230	8·7590	1·48810
623	388129	241804367	24·9600	8·5408	1·60514	**673**	452929	304821217	25·9422	8·7634	1·48588
624	389376	242970624	24·9800	8·5453	1·60256	**674**	454276	306182024	25·9615	8·7677	1·48368
625	390625	244140625	25·0000	8·5499	1·60000	**675**	455625	307546875	25·9808	8·7721	1·48148
626	391876	245314376	25·0200	8·5544	1·59744	**676**	456976	308915776	26·0000	8·7764	1·47929
627	393129	246491883	25·0400	8·5590	1·59490	**677**	458329	310288733	26·0192	8·7807	1·47711
628	394384	247673152	25·0599	8·5635	1·59236	**678**	459684	311665752	26·0384	8·7850	1·47493
629	395641	248858189	25·0799	8·5681	1·58983	**679**	461041	313046839	26·0576	8·7893	1·47275
630	396900	250047000	25·0998	8·5726	1·58730	**680**	462400	314432000	26·0768	8·7937	1·47059
631	398161	251239591	25·1197	8·5772	1·58479	**681**	463761	315821241	26·0960	8·7980	1·46843
632	399424	252435968	25·1396	8·5817	1·58228	**682**	465124	317214568	26·1151	8·8023	1·46628
633	400689	253636137	25·1595	8·5862	1·57978	**683**	466489	318611987	26·1343	8·8066	1·46413
634	401956	254840104	25·1794	8·5907	1·57729	**684**	467856	320013504	26·1534	8·8109	1·46199
635	403225	256047875	25·1992	8·5952	1·57480	**685**	469225	321419125	26·1725	8·8152	1·45985
636	404496	257259456	25·2190	8·5997	1·57233	**686**	470596	322828856	26·1916	8·8194	1·45773
637	405769	258474853	25·2389	8·6043	1·56986	**687**	471969	324242703	26·2107	8·8237	1·45560
638	407044	259694072	25·2587	8·6088	1·56740	**688**	473344	325660672	26·2298	8·8280	1·45349
639	408321	260917119	25·2784	8·6132	1·56495	**689**	474721	327082769	26·2488	8·8323	1·45138
640	409600	262144000	25·2982	8·6177	1·56250	**690**	476100	328509000	26·2679	8·8366	1·44928
641	410881	263374721	25·3180	8·6222	1·56006	**691**	477481	329939371	26·2869	8·8408	1·44718
642	412164	264609288	25·3377	8·6267	1·55763	**692**	478864	331373888	26·3059	8·8451	1·44509
643	413449	265847707	25·3574	8·6312	1·55521	**693**	480249	332812557	26·3249	8·8493	1·44300
644	414736	267089984	25·3772	8·6357	1·55280	**694**	481636	334255384	26·3439	8·8536	1·44092
645	416025	268336125	25·3969	8·6401	1·55039	**695**	483025	335702375	26·3629	8·8578	1·43885
646	417316	269586136	25·4165	8·6446	1·54799	**696**	484416	337153536	26·3818	8·8621	1·43678
647	418609	270840023	25·4362	8·6490	1·54560	**697**	485809	338608873	26·4008	8·8663	1·43472
648	419904	272097792	25·4558	8·6535	1·54321	**698**	487204	340068392	26·4197	8·8706	1·43267
649	421201	273359449	25·4755	8·6579	1·54083	**699**	488601	341532099	26·4386	8·8748	1·43062
650	422500	274625000	25·4951	8·6624	1·53846	**700**	490000	343000000	26·4575	8·8790	1·42857

FUNCTIONS OF NUMBERS.

701 TO 800.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal.
701	491401	344472101	26·4764	8·8833	1·42653	**751**	564001	423564751	27·4044	9·0896	1·33156
702	492804	345948408	26·4953	8·8875	1·42450	**752**	565504	425259008	27·4226	9·0937	1·32979
703	494209	347428927	26·5141	8·8917	1·42248	**753**	567009	426957777	27·4408	9·0977	1·32802
704	495616	348913664	26·5330	8·8959	1·42046	**754**	568516	428661064	27·4591	9·1017	1·32626
705	497025	350402625	26·5518	8·9001	1·41844	**755**	570025	430368875	27·4773	9·1057	1·32450
706	498436	351895816	26·5707	8·9043	1·41643	**756**	571536	432081216	27·4955	9·1098	1·32275
707	499849	353393243	26·5895	8·9085	1·41443	**757**	573049	433798093	27·5136	9·1138	1·32100
708	501264	354894912	26·6083	8·9127	1·41243	**758**	574564	435519512	27·5318	9·1178	1·31926
709	502681	356400829	26·6271	8·9169	1·41044	**759**	576081	437245479	27·5500	9·1218	1·31752
710	504100	357911000	26·6458	8·9211	1·40845	**760**	577600	438976000	27·5681	9·1258	1·31579
711	505521	359425431	26·6646	8·9253	1·40647	**761**	579121	440711081	27·5862	9·1298	1·31406
712	506944	360944128	26·6833	8·9295	1·40449	**762**	580644	442450728	27·6043	9·1338	1·31234
713	508369	362467097	26·7021	8·9337	1·40253	**763**	582169	444194947	27·6225	9·1378	1·31062
714	509796	363994344	26·7208	8·9378	1·40056	**764**	583696	445943744	27·6405	9·1418	1·30890
715	511225	365525875	26·7395	8·9420	1·39860	**765**	585225	447697125	27·6586	9·1458	1·30719
716	512656	367061696	26·7582	8·9462	1·39665	**766**	586756	449455096	27·6767	9·1498	1·30548
717	514089	368601813	26·7769	8·9503	1·39470	**767**	588289	451217663	27·6948	9·1537	1·30378
718	515524	370146232	26·7955	8·9545	1·39276	**768**	589824	452984832	27·7128	9·1577	1·30208
719	516961	371694959	26·8142	8·9587	1·39082	**769**	591361	454756609	27·7308	9·1617	1·30039
720	518400	373248000	26·8328	8·9628	1·38889	**770**	592900	456533000	27·7489	9·1657	1·29870
721	519841	374805361	26·8514	8·9670	1·38696	**771**	594441	458314011	27·7669	9·1696	1·29702
722	521284	376367048	26·8701	8·9711	1·38504	**772**	595984	460099648	27·7849	9·1736	1·29534
723	522729	377933067	26·8887	8·9752	1·38313	**773**	597529	461889917	27·8029	9·1775	1·29366
724	524176	379503424	26·9072	8·9794	1·38122	**774**	599076	463684824	27·8209	9·1815	1·29199
725	525625	381078125	26·9258	8·9835	1·37931	**775**	600625	465484375	27·8388	9·1855	1·29032
726	527076	382657176	26·9444	8·9876	1·37741	**776**	602176	467288576	27·8568	9·1894	1·28866
727	528529	384240583	26·9629	8·9918	1·37552	**777**	603729	469097433	27·8747	9·1933	1·28700
728	529984	385828352	26·9815	8·9959	1·37363	**778**	605284	470910952	27·8927	9·1973	1·28535
729	531441	387420489	27·0000	9·0000	1·37174	**779**	606841	472729139	27·9106	9·2012	1·28370
730	532900	389017000	27·0185	9·0041	1·36986	**780**	608400	474552000	27·9285	9·2052	1·28205
731	534361	390617891	27·0370	9·0082	1·36799	**781**	609961	476379541	27·9464	9·2091	1·28041
732	535824	392223168	27·0555	9·0123	1·36612	**782**	611524	478211768	27·9643	9·2130	1·27877
733	537289	393832837	27·0740	9·0164	1·36426	**783**	613089	480048687	27·9821	9·2170	1·27714
734	538756	395446904	27·0924	9·0205	1·36240	**784**	614656	481890304	28·0000	9·2209	1·27551
735	540225	397065375	27·1109	9·0246	1·36054	**785**	616225	483736625	28·0179	9·2248	1·27389
736	541696	398688256	27·1293	9·0287	1·35870	**786**	617796	485587656	28·0357	9·2287	1·27226
737	543169	400315553	27·1477	9·0328	1·35685	**787**	619369	487443403	28·0535	9·2326	1·27065
738	544644	401947272	27·1662	9·0369	1·35501	**788**	620944	489303872	28·0713	9·2365	1·26904
739	546121	403583419	27·1846	9·0410	1·35318	**789**	622521	491169069	28·0891	9·2404	1·26743
740	547600	405224000	27·2029	9·0450	1·35135	**790**	624100	493039000	28·1069	9·2443	1·26582
741	549081	406869021	27·2213	9·0491	1·34953	**791**	625681	494913671	28·1247	9·2482	1·26422
742	550564	408518488	27·2397	9·0532	1·34771	**792**	627264	496793088	28·1425	9·2521	1·26263
743	552049	410172407	27·2580	9·0572	1·34590	**793**	628849	498677257	28·1603	9·2560	1·26103
744	553536	411830784	27·2764	9·0613	1·34409	**794**	630436	500566184	28·1780	9·2599	1·25945
745	555025	413493625	27·2947	9·0654	1·34228	**795**	632025	502459875	28·1957	9·2638	1·25786
746	556516	415160936	27·3130	9·0694	1·34048	**796**	633616	504358336	28·2135	9·2677	1·25628
747	558009	416832723	27·3313	9·0735	1·33869	**797**	635209	506261573	28·2312	9·2716	1·25471
748	559504	418508992	27·3496	9·0775	1·33690	**798**	636804	508169592	28·2489	9·2754	1·25313
749	561001	420189749	27·3679	9·0816	1·33511	**799**	638401	510082399	28·2666	9·2793	1·25156
750	562500	421875000	27·3861	9·0856	1·33333	**800**	640000	512000000	28·2843	9·2832	1·25000

FUNCTIONS OF NUMBERS.

801 TO 900.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
801	641601	513922401	28·3019	9·2870	1·24844	**851**	724201	616295051	29·1719	9·4764	1·17509
802	643204	515849608	28·3196	9·2909	1·24688	**852**	725904	618470208	29·1890	9·4801	1·17371
803	644809	517781627	28·3373	9·2948	1·24533	**853**	727609	620650477	29·2062	9·4838	1·17233
804	646416	519718464	28·3549	9·2986	1·24378	**854**	729316	622835864	29·2233	9·4875	1·17096
805	648025	521660125	28·3725	9·3025	1·24224	**855**	731025	625026375	29·2404	9·4912	1·16959
806	649636	523606616	28·3901	9·3063	1·24069	**856**	732736	627222016	29·2575	9·4949	1·16822
807	651249	525557943	28·4077	9·3102	1·23916	**857**	734449	629422793	29·2746	9·4986	1·16686
808	652864	527514112	28·4253	9·3140	1·23762	**858**	736164	631628712	29·2916	9·5023	1·16550
809	654481	529475129	28·4429	9·3179	1·23609	**859**	737881	633839779	29·3087	9·5060	1·16414
810	656100	531441000	28·4605	9·3217	1·23457	**860**	739600	636056000	29·3258	9·5097	1·16279
811	657721	533411731	28·4781	9·3255	1·23305	**861**	741321	638277381	29·3428	9·5134	1·16144
812	659344	535387328	28·4956	9·3294	1·23153	**862**	743044	640503928	29·3598	9·5171	1·16009
813	660969	537367797	28·5132	9·3332	1·23001	**863**	744769	642735647	29·3769	9·5207	1·15875
814	662596	539353144	28·5307	9·3370	1·22850	**864**	746496	644972544	29·3939	9·5244	1·15741
815	664225	541343375	28·5482	9·3408	1·22699	**865**	748225	647214625	29·4109	9·5281	1·15607
816	665856	543338496	28·5657	9·3447	1·22549	**866**	749956	649461896	29·4279	9·5317	1·15473
817	667489	545338513	28·5832	9·3485	1·22399	**867**	751689	651714363	29·4449	9·5354	1·15340
818	669124	547343432	28·6007	9·3523	1·22249	**868**	753424	653972032	29·4618	9·5391	1·15207
819	670761	549353259	28·6182	9·3561	1·22100	**869**	755161	656234909	29·4788	9·5427	1·15075
820	672400	551368000	28·6356	9·3599	1·21951	**870**	756900	658503000	29·4958	9·5464	1·14943
821	674041	553387661	28·6531	9·3637	1·21803	**871**	758641	660776311	29·5127	9·5501	1·14811
822	675684	555412248	28·6705	9·3675	1·21655	**872**	760384	663054848	29·5296	9·5537	1·14679
823	677329	557441767	28·6880	9·3713	1·21507	**873**	762129	665338617	29·5466	9·5574	1·14548
824	678976	559476224	28·7054	9·3751	1·21359	**874**	763876	667627624	29·5635	9·5610	1·14416
825	680625	561515625	28·7228	9·3789	1·21212	**875**	765625	669921875	29·5804	9·5647	1·14286
826	682276	563559976	28·7402	9·3827	1·21065	**876**	767376	672221376	29·5973	9·5683	1·14155
827	683929	565609283	28·7576	9·3865	1·20919	**877**	769129	674526133	29·6142	9·5719	1·14025
828	685584	567663552	28·7750	9·3902	1·20773	**878**	770884	676836152	29·6311	9·5756	1·13895
829	687241	569722789	28·7924	9·3940	1·20627	**879**	772641	679151439	29·6479	9·5792	1·13766
830	688900	571787000	28·8097	9·3978	1·20482	**880**	774400	681472000	29·6648	9·5828	1·13636
831	690561	573856191	28·8271	9·4016	1·20337	**881**	776161	683797841	29·6816	9·5865	1·13507
832	692224	575930368	28·8444	9·4053	1·20192	**882**	777924	686128968	29·6985	9·5901	1·13379
833	693889	578009537	28·8617	9·4091	1·20048	**883**	779689	688465387	29·7153	9·5937	1·13250
834	695556	580093704	28·8791	9·4129	1·19904	**884**	781456	690807104	29·7321	9·5973	1·13122
835	697225	582182875	28·8964	9·4166	1·19760	**885**	783225	693154125	29·7489	9·6010	1·12994
836	698896	584277056	28·9137	9·4204	1·19617	**886**	784996	695506456	29·7658	9·6046	1·12867
837	700569	586376253	28·9310	9·4241	1·19474	**887**	786769	697864103	29·7825	9·6082	1·12740
838	702244	588480472	28·9482	9·4279	1·19332	**888**	788544	700227072	29·7993	9·6118	1·12613
839	703921	590589719	28·9655	9·4316	1·19189	**889**	790321	702595369	29·8161	9·6154	1·12486
840	705600	592704000	28·9828	9·4354	1·19048	**890**	792100	704969000	29·8329	9·6190	1·12360
841	707281	594823321	29·0000	9·4391	1·18906	**891**	793881	707347971	29·8496	9·6226	1·12233
842	708964	596947688	29·0172	9·4429	1·18765	**892**	795664	709732288	29·8664	9·6262	1·12108
843	710649	599077107	29·0345	9·4466	1·18624	**893**	797449	712121957	29·8831	9·6298	1·11982
844	712336	601211584	29·0517	9·4503	1·18483	**894**	799236	714516984	29·8998	9·6334	1·11857
845	714025	603351125	29·0689	9·4541	1·18343	**895**	801025	716917375	29·9166	9·6370	1·11732
846	715716	605495736	29·0861	9·4578	1·18203	**896**	802816	719323136	29·9333	9·6406	1·11607
847	717409	607645423	29·1033	9·4615	1·18064	**897**	804609	721734273	29·9500	9·6442	1·11483
848	719104	609800192	29·1204	9·4652	1·17925	**898**	806404	724150792	29·9666	9·6477	1·11359
849	720801	611960049	29·1376	9·4690	1·17786	**899**	808201	726572699	29·9833	9·6513	1·11235
850	722500	614125000	29·1548	9·4727	1·17647	**900**	810000	729000000	30·0000	9·6549	1·11111

FUNCTIONS OF NUMBERS.

901 TO 999.

No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal	No.	Square.	Cube.	Square Root.	Cube Root.	1000 × Reciprocal
901	811801	731432701	30·0167	9·6585	1·10988	**951**	904401	860085351	30·8383	9·8339	1·05152
902	813604	733870808	30·0333	9·6620	1·10865	**952**	906304	862801408	30·8545	9·8374	1·05042
903	815409	736314327	30·0500	9·6656	1·10742	**953**	908209	865523177	30·8707	9·8408	1·04932
904	817216	738763264	30·0666	9·6692	1·10619	**954**	910116	868250664	30·8869	9·8443	1·04822
905	819025	741217625	30·0832	9·6727	1·10497	**955**	912025	870983875	30·9031	9·8477	1·04712
906	820836	743677416	30·0998	9·6763	1·10375	**956**	913936	873722816	30·9192	9·8511	1·04603
907	822649	746142643	30·1164	9·6799	1·10254	**957**	915849	876467493	30·9354	9·8546	1·04493
908	824464	748613312	30·1330	9·6834	1·10132	**958**	917764	879217912	30·9516	9·8580	1·04384
909	826281	751089429	30·1496	9·6870	1·10011	**959**	919681	881974079	30·9677	9·8614	1·04275
910	828100	753571000	30·1662	9·6905	1·09890	**960**	921600	884736000	30·9839	9·8648	1·04167
911	829921	756058031	30·1828	9·6941	1·09769	**961**	923521	887503681	31·0000	9·8683	1·04058
912	831744	758550528	30·1993	9·6976	1·09649	**962**	925444	890277128	31·0161	9·8717	1·03950
913	833569	761048497	30·2159	9·7012	1·09529	**963**	927369	893056347	31·0322	9·8751	1·03842
914	835396	763551944	30·2324	9·7047	1·09409	**964**	929296	895841344	31·0483	9·8785	1·03734
915	837225	766060875	30·2490	9·7082	1·09290	**965**	931225	898632125	31·0644	9·8819	1·03627
916	839056	768575296	30·2655	9·7118	1·09170	**966**	933156	901428696	31·0805	9·8854	1·03520
917	840889	771095213	30·2820	9·7153	1·09051	**967**	935089	904231063	31·0966	9·8888	1·03413
918	842724	773620632	30·2985	9·7188	1·08932	**968**	937024	907039232	31·1127	9·8922	1·03306
919	844561	776151559	30·3150	9·7224	1·08814	**969**	938961	909853209	31·1288	9·8956	1·03199
920	846400	778688000	30·3315	9·7259	1·08696	**970**	940900	912673000	31·1448	9·8990	1·03093
921	848241	781229961	30·3480	9·7294	1·08578	**971**	942841	915498611	31·1609	9·9024	1·02987
922	850084	783777448	30·3645	9·7329	1·08460	**972**	944784	918330048	31·1769	9·9058	1·02881
923	851929	786330467	30·3809	9·7364	1·08342	**973**	946729	921167317	31·1929	9·9092	1·02775
924	853776	788889024	30·3974	9·7400	1·08225	**974**	948676	924010424	31·2090	9·9126	1·02669
925	855625	791453125	30·4138	9·7435	1·08108	**975**	950625	926859375	31·2250	9·9160	1·02564
926	857476	794022776	30·4302	9·7470	1·07991	**976**	952576	929714176	31·2410	9·9194	1·02459
927	859329	796597983	30·4467	9·7505	1·07875	**977**	954529	932574833	31·2570	9·9227	1·02354
928	861184	799178752	30·4631	9·7540	1·07759	**978**	956484	935441352	31·2730	9·9261	1·02249
929	863041	801765089	30·4795	9·7575	1·07643	**979**	958441	938313739	31·2890	9·9295	1·02145
930	864900	804357000	30·4959	9·7610	1·07527	**980**	960400	941192000	31·3050	9·9329	1·02041
931	866761	806954491	30·5123	9·7645	1·07411	**981**	962361	944076141	31·3209	9·9363	1·01937
932	868624	809557568	30·5287	9·7680	1·07296	**982**	964324	946966168	31·3369	9·9396	1·01833
933	870489	812166237	30·5450	9·7715	1·07181	**983**	966289	949862087	31·3528	9·9430	1·01729
934	872356	814780504	30·5614	9·7750	1·07066	**984**	968256	952763904	31·3688	9·9464	1·01626
935	874225	817400375	30·5778	9·7785	1·06952	**985**	970225	955671625	31·3847	9·9497	1·01523
936	876096	820025856	30·5941	9·7819	1·06838	**986**	972196	958585256	31·4006	9·9531	1·01420
937	877969	822656953	30·6105	9·7854	1·06724	**987**	974169	961504803	31·4166	9·9565	1·01317
938	879844	825293672	30·6268	9·7889	1·06610	**988**	976144	964430272	31·4325	9·9598	1·01215
939	881721	827936019	30·6431	9·7924	1·06496	**989**	978121	967361669	31·4484	9·9632	1·01112
940	883600	830584000	30·6594	9·7959	1·06383	**990**	980100	970299000	31·4643	9·9666	1·01010
941	885481	833237621	30·6757	9·7993	1·06270	**991**	982081	973242271	31·4802	9·9699	1·00908
942	887364	835896888	30·6920	9·8028	1·06157	**992**	984064	976191488	31·4960	9·9733	1·00806
943	889249	838561807	30·7083	9·8063	1·06045	**993**	986049	979146657	31·5119	9·9766	1·00705
944	891136	841232384	30·7246	9·8097	1·05932	**994**	988036	982107784	31·5278	9·9800	1·00604
945	893025	843908625	30·7409	9·8132	1·05820	**995**	990025	985074875	31·5436	9·9833	1·00503
946	894916	846590536	30·7571	9·8167	1·05708	**996**	992016	988047936	31·5595	9·9866	1·00402
947	896809	849278123	30·7734	9·8201	1·05597	**997**	994009	991026973	31·5753	9·9900	1·00301
948	898704	851971392	30·7896	9·8236	1·05485	**998**	996004	994011992	31·5911	9·9933	1·00200
949	900601	854670349	30·8058	9·8270	1·05374	**999**	998001	997002999	31·6070	9·9967	1·00100
950	902500	857375000	30·8221	9·8305	1·05263						

AREAS AND CIRCUMFERENCES OF CIRCLES.

1 TO 250.

Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.
1	0·7854	3·142	**51**	2042·82	160·22	**101**	8011·85	317·30	**151**	17907·9	474·38	**201**	31730·9	631·46
2	3·1416	6·283	**52**	2123·72	163·36	**102**	8171·28	320·44	**152**	18145·8	477·52	**202**	32047·4	634·60
3	7·0686	9·425	**53**	2206·18	166·50	**103**	8332·29	323·58	**153**	18385·4	480·66	**203**	32365·5	637·74
4	12·5664	12·566	**54**	2290·22	169·65	**104**	8494·87	326·73	**154**	18626·5	483·81	**204**	32685·1	640·89
5	19·6350	15·708	**55**	2375·83	172·79	**105**	8659·01	329·87	**155**	18869·2	486·95	**205**	33006·4	644·03
6	28·2743	18·850	**56**	2463·01	175·93	**106**	8824·73	333·01	**156**	19113·4	490·09	**206**	33329·2	647·17
7	38·4845	21·991	**57**	2551·76	179·07	**107**	8992·02	336·15	**157**	19359·3	493·23	**207**	33653·5	650·31
8	50·2655	25·133	**58**	2642·08	182·21	**108**	9160·88	339·29	**158**	19606·7	496·37	**208**	33979·5	653·45
9	63·6173	28·274	**59**	2733·97	185·35	**109**	9331·32	342·43	**159**	19855·7	499·51	**209**	34307·0	656·59
10	78·5398	31·416	**60**	2827·43	188·50	**110**	9503·32	345·58	**160**	20106·2	502·65	**210**	34636·1	659·73
11	95·0332	34·558	**61**	2922·47	191·64	**111**	9676·89	348·72	**161**	20358·3	505·80	**211**	34966·7	662·88
12	113·097	37·699	**62**	3019·07	194·78	**112**	9852·03	351·86	**162**	20612·0	508·94	**212**	35298·9	666·02
13	132·732	40·841	**63**	3117·25	197·92	**113**	10028·7	355·00	**163**	20867·2	512·08	**213**	35632·7	669·16
14	153·938	43·982	**64**	3216·99	201·06	**114**	10207·0	358·14	**164**	21124·1	515·22	**214**	35968·1	672·30
15	176·715	47·124	**65**	3318·31	204·20	**115**	10386·9	361·28	**165**	21382·5	518·36	**215**	36305·0	675·44
16	201·062	50·265	**66**	3421·19	207·35	**116**	10568·3	364·42	**166**	21642·4	521·50	**216**	36643·5	678·58
17	226·980	53·407	**67**	3525·65	210·49	**117**	10751·3	367·57	**167**	21904·0	524·65	**217**	36983·6	681·73
18	254·469	56·549	**68**	3631·68	213·63	**118**	10935·9	370·71	**168**	22167·1	527·79	**218**	37325·3	684·87
19	283·529	59·690	**69**	3739·28	216·77	**119**	11122·0	373·85	**169**	22431·8	530·93	**219**	37668·5	688·01
20	314·159	62·832	**70**	3848·45	219·91	**120**	11309·7	376·99	**170**	22698·0	534·07	**220**	38013·3	691·15
21	346·361	65·973	**71**	3959·19	223·05	**121**	11499·0	380·13	**171**	22965·8	537·21	**221**	38359·6	694·29
22	380·133	69·115	**72**	4071·50	226·19	**122**	11689·9	383·27	**172**	23235·2	540·35	**222**	38707·6	697·43
23	415·476	72·257	**73**	4185·39	229·34	**123**	11882·3	386·42	**173**	23506·2	543·50	**223**	39057·1	700·58
24	452·389	75·398	**74**	4300·84	232·48	**124**	12076·3	389·56	**174**	23778·7	546·64	**224**	39408·1	703·72
25	490·874	78·540	**75**	4417·86	235·62	**125**	12271·8	392·70	**175**	24052·8	549·78	**225**	39760·8	706·86
26	530·929	81·681	**76**	4536·46	238·76	**126**	12469·0	395·84	**176**	24328·5	552·92	**226**	40115·0	710·00
27	572·555	84·823	**77**	4656·63	241·90	**127**	12667·7	398·98	**177**	24605·7	556·06	**227**	40470·8	713·14
28	615·752	87·965	**78**	4778·36	245·04	**128**	12868·0	402·12	**178**	24884·6	559·20	**228**	40828·1	716·28
29	660·520	91·106	**79**	4901·67	248·19	**129**	13069·8	405·27	**179**	25164·9	562·35	**229**	41187·1	719·42
30	706·858	94·248	**80**	5026·55	251·33	**130**	13273·2	408·41	**180**	25446·9	565·49	**230**	41547·6	722·57
31	754·768	97·389	**81**	5153·00	254·47	**131**	13478·2	411·55	**181**	25730·4	568·63	**231**	41909·6	725·71
32	804·248	100·531	**82**	5281·02	257·61	**132**	13684·8	414·69	**182**	26015·5	571·77	**232**	42273·3	728·85
33	855·299	103·673	**83**	5410·61	260·75	**133**	13892·9	417·83	**183**	26302·2	574·91	**233**	42638·5	731·99
34	907·920	106·814	**84**	5541·77	263·89	**134**	14102·6	420·97	**184**	26590·4	578·05	**234**	43005·3	735·13
35	962·113	109·956	**85**	5674·50	267·04	**135**	14313·9	424·12	**185**	26880·3	581·19	**235**	43873·6	738·27
36	1017·88	113·097	**86**	5808·80	270·18	**136**	14526·7	427·26	**186**	27171·6	584·34	**236**	43743·5	741·42
37	1075·21	116·239	**87**	5944·68	273·32	**137**	14741·1	430·40	**187**	27464·6	587·48	**237**	44115·0	744·56
38	1134·11	119·381	**88**	6082·12	276·46	**138**	14957·1	433·54	**188**	27759·1	590·62	**238**	44488·1	747·70
39	1194·59	122·522	**89**	6221·14	279·60	**139**	15174·7	436·68	**189**	28055·2	593·76	**239**	44862·7	750·84
40	1256·64	125·660	**90**	6361·73	282·74	**140**	15393·8	439·82	**190**	28352·9	596·90	**240**	45238·9	753·98
41	1320·25	128·806	**91**	6503·88	285·88	**141**	15614·5	442·96	**191**	28652·1	600·04	**241**	45616·7	757·12
42	1385·44	131·947	**92**	6647·61	289·03	**142**	15836·8	446·11	**192**	28952·9	603·19	**242**	45996·1	760·27
43	1452·20	135·090	**93**	6792·91	292·17	**143**	16060·6	449·25	**193**	29255·3	606·33	**243**	46377·0	763·41
44	1520·53	138·230	**94**	6939·78	295·31	**144**	16286·0	452·39	**194**	29559·2	609·47	**244**	46759·5	766·55
45	1590·43	141·372	**95**	7088·22	298·45	**145**	16513·0	455·53	**195**	29864·8	612·61	**245**	47143·5	769·69
46	1661·90	144·514	**96**	7238·23	301·59	**146**	16741·5	458·67	**196**	30171·9	615·75	**246**	47529·2	772·83
47	1734·94	147·655	**97**	7389·81	304·73	**147**	16971·7	461·81	**197**	30480·5	618·89	**247**	47916·4	775·97
48	1809·56	150·800	**98**	7542·96	307·88	**148**	17203·4	464·96	**198**	30790·7	622·04	**248**	48305·1	779·12
49	1885·74	153·938	**99**	7697·69	311·02	**149**	17436·6	468·10	**199**	31102·6	625·18	**249**	48695·5	782·26
50	1963·50	157·080	**100**	7853·98	314·16	**150**	17671·5	471·24	**200**	31415·9	628·32	**250**	49087·4	785·40

AREAS AND CIRCUMFERENCES OF CIRCLES.
251 TO 500.

Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.
251	49480·9	788·54	**301**	71157·9	945·62	**351**	96761·8	1102·7	**401**	126293	1259·8	**451**	159751	1416·9
252	49875·9	791·68	**302**	71631·5	948·76	**352**	97314·0	1105·8	**402**	126923	1262·9	**452**	160460	1420·0
253	50272·6	794·82	**303**	72106·6	951·90	**353**	97867·7	1109·0	**403**	127556	1266·1	**453**	161171	1423·1
254	50670·7	797·96	**304**	72583·4	955·04	**354**	98423·0	1112·1	**404**	128190	1269·2	**454**	161883	1426·3
255	51070·5	801·11	**305**	73061·7	958·19	**355**	98979·8	1115·3	**405**	128825	1272·3	**455**	162597	1429·4
256	51471·9	804·25	**306**	73541·5	961·33	**356**	99538·2	1118·4	**406**	129462	1275·5	**456**	163313	1432·6
257	51874·8	807·39	**307**	74023·0	964·47	**357**	100098	1121·5	**407**	130100	1278·6	**457**	164030	1435·7
258	52279·2	810·53	**308**	74506·0	967·61	**358**	100660	1124·7	**408**	130741	1281·8	**458**	164748	1438·9
259	52685·3	813·67	**309**	74990·6	970·75	**359**	101223	1127·8	**409**	131382	1284·9	**459**	165468	1442·0
260	53092·9	816·81	**310**	75476·8	973·89	**360**	101788	1131·0	**410**	132025	1288·1	**460**	166190	1445·1
261	53502·1	819·96	**311**	75964·5	977·04	**361**	102354	1134·1	**411**	132670	1291·2	**461**	166914	1448·3
262	53912·9	823·10	**312**	76453·8	980·18	**362**	102922	1137·3	**412**	133317	1294·3	**462**	167639	1451·4
263	54325·2	826·24	**313**	76944·7	983·32	**363**	103491	1140·4	**413**	133965	1297·5	**463**	168365	1454·6
264	54739·1	829·38	**314**	77437·1	986·46	**364**	104062	1143·5	**414**	134614	1300·6	**464**	169093	1457·7
265	55154·6	832·52	**315**	77931·1	989·60	**365**	104635	1146·7	**415**	135265	1303·8	**465**	169823	1460·8
266	55571·6	835·66	**316**	78426·7	992·74	**366**	105209	1149·8	**416**	135918	1306·9	**466**	170554	1464·0
267	55990·3	838·81	**317**	78923·9	995·88	**367**	105785	1153·0	**417**	136572	1310·0	**467**	171287	1467·1
268	56410·4	841·95	**318**	79422·6	999·03	**368**	106362	1156·1	**418**	137228	1313·2	**468**	172021	1470·3
269	56832·2	845·09	**319**	79922·9	1002·2	**369**	106941	1159·2	**419**	137885	1316·3	**469**	172757	1473·4
270	57255·5	848·23	**320**	80424·8	1005·3	**370**	107521	1162·4	**420**	138544	1319·5	**470**	173494	1476·5
271	57680·4	851·37	**321**	80928·2	1008·5	**371**	108103	1165·5	**421**	139205	1322·6	**471**	174234	1479·7
272	58106·9	854·51	**322**	81433·2	1011·6	**372**	108687	1168·7	**422**	139867	1325·8	**472**	174974	1482·8
273	58534·9	857·66	**323**	81939·8	1014·7	**373**	109272	1171·8	**423**	140531	1328·9	**473**	175716	1486·0
274	58964·6	860·80	**324**	82448·0	1017·9	**374**	109858	1175·0	**424**	141196	1332·0	**474**	176460	1489·1
275	59395·7	863·94	**325**	82957·7	1021·0	**375**	110447	1178·1	**425**	141863	1335·2	**475**	177205	1492·3
276	59828·5	867·08	**326**	83469·0	1024·2	**376**	111036	1181·2	**426**	142531	1338·3	**476**	177952	1495·4
277	60262·8	870·22	**327**	83981·8	1027·3	**377**	111628	1184·4	**427**	143201	1341·5	**477**	178701	1498·5
278	60698·7	873·36	**328**	84496·3	1030·4	**378**	112221	1187·5	**428**	143872	1344·6	**478**	179451	1501·7
279	61136·2	876·50	**329**	85012·3	1033·6	**379**	112815	1190·7	**429**	144545	1347·7	**479**	180203	1504·8
280	61575·2	879·65	**330**	85529·9	1036·7	**380**	113411	1193·8	**430**	145220	1350·9	**480**	180956	1508·0
281	62015·8	882·79	**331**	86049·0	1039·9	**381**	114009	1196·9	**431**	145896	1354·0	**481**	181711	1511·1
282	62458·0	885·93	**332**	86569·7	1043·0	**382**	114608	1200·1	**432**	146574	1357·2	**482**	182467	1514·3
283	62901·8	889·07	**333**	87092·0	1046·2	**383**	115209	1203·2	**433**	147254	1360·3	**483**	183225	1517·4
284	63347·1	892·21	**334**	87615·9	1049·3	**384**	115812	1206·4	**434**	147934	1363·5	**484**	183984	1520·5
285	63794·0	895·35	**335**	88141·3	1052·4	**385**	116416	1209·5	**435**	148617	1366·6	**485**	184745	1523·7
286	64242·4	898·50	**336**	88668·3	1055·6	**386**	117021	1212·7	**436**	149301	1369·7	**486**	185508	1526·8
287	64692·5	901·64	**337**	89196·9	1058·7	**387**	117628	1215·8	**437**	149987	1372·9	**487**	186272	1530·0
288	65144·1	904·78	**338**	89727·0	1061·9	**388**	118237	1218·9	**438**	150674	1376·0	**488**	187038	1533·1
289	65597·2	907·92	**339**	90258·7	1065·0	**389**	118847	1222·1	**439**	151363	1379·2	**489**	187805	1536·2
290	66052·0	911·06	**340**	90792·0	1068·1	**390**	119459	1225·2	**440**	152053	1382·3	**490**	188574	1539·4
291	66508·3	914·20	**341**	91326·9	1071·3	**391**	120072	1228·4	**441**	152745	1385·4	**491**	189345	1542·5
292	66966·2	917·35	**342**	91863·3	1074·4	**392**	120687	1231·5	**442**	153439	1388·6	**492**	190117	1545·7
293	67425·6	920·49	**343**	92401·3	1077·6	**393**	121304	1234·6	**443**	154134	1391·7	**493**	190890	1548·8
294	67886·7	923·63	**344**	92940·9	1080·7	**394**	121922	1237·8	**444**	154830	1394·9	**494**	191665	1551·9
295	68349·3	926·77	**345**	93482·0	1083·8	**395**	122542	1240·9	**445**	155528	1398·0	**495**	192442	1555·1
296	68813·5	929·91	**346**	94024·7	1087·0	**396**	123163	1244·1	**446**	156228	1401·2	**496**	193221	1558·2
297	69279·2	933·05	**347**	94569·0	1090·1	**397**	123786	1247·2	**447**	156930	1404·3	**497**	194000	1561·4
298	69746·5	936·19	**348**	95114·9	1093·3	**398**	124410	1250·4	**448**	157633	1407·4	**498**	194782	1564·5
299	70215·4	939·34	**349**	95662·3	1096·4	**399**	125036	1253·5	**449**	158337	1410·6	**499**	195565	1567·7
300	70685·8	942·48	**350**	96211·3	1099·6	**400**	125664	1256·6	**450**	159043	1413·7	**500**	196350	1570·8

Index, Code.

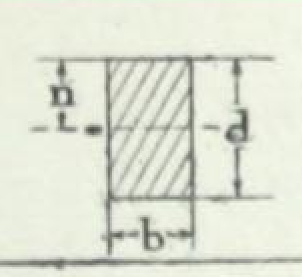
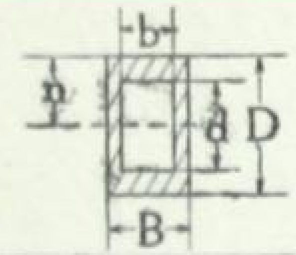
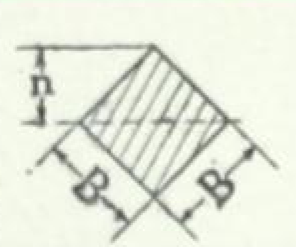
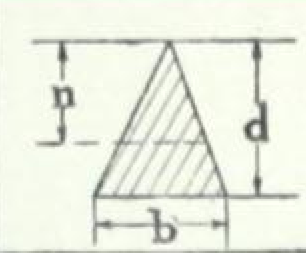
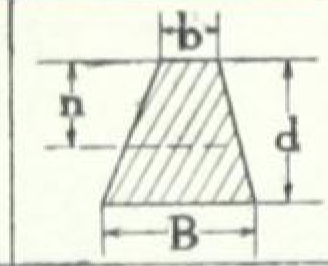
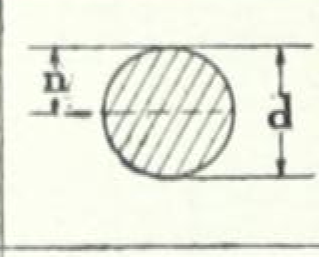
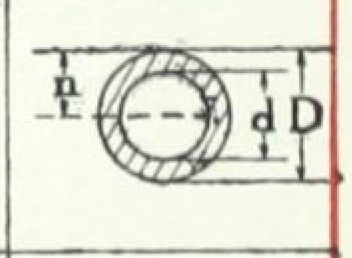
AREAS AND CIRCUMFERENCES OF CIRCLES.
501 TO 750.

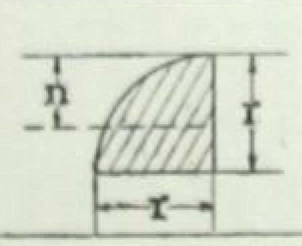
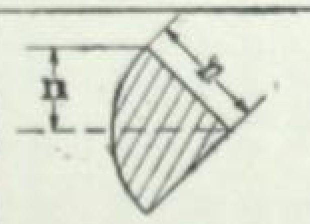
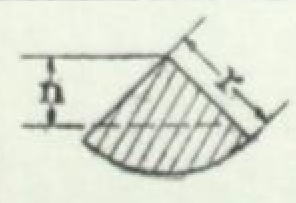
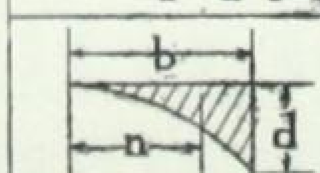
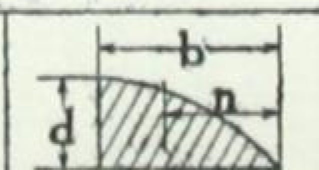
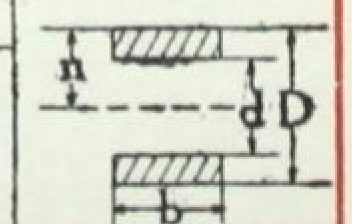
Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.
501	197136	1573·9	551	238448	1731·0	601	283687	1888·1	651	332853	2045·2	701	385945	2202·3
502	197923	1577·1	552	239314	1734·2	602	284631	1891·2	652	333876	2048·3	702	387047	2205·4
503	198713	1580·2	553	240182	1737·3	603	285578	1894·4	653	334901	2051·5	703	388151	2208·5
504	199504	1583·4	554	241051	1740·4	604	286526	1897·5	654	335927	2054·6	704	389256	2211·7
505	200296	1586·5	555	241922	1743·6	605	287475	1900·7	655	336955	2057·7	705	390363	2214·8
506	201090	1589·7	556	242795	1746·7	606	288426	1903·8	656	337985	2060·9	706	391471	2218·0
507	201886	1592·8	557	243669	1749·9	607	289379	1907·0	657	339016	2064·0	707	392580	2221·1
508	202683	1595·9	558	244545	1753·0	608	290333	1910·1	658	340049	2067·2	708	393692	2224·3
509	203482	1599·1	559	245422	1756·2	609	291289	1913·2	659	341083	2070·3	709	394805	2227·4
510	204282	1602·2	560	246301	1759·3	610	292247	1916·4	660	342119	2073·5	710	395919	2230·5
511	205084	1605·4	561	247181	1762·4	611	293206	1919·5	661	343157	2076·6	711	397035	2233·7
512	205887	1608·5	562	248063	1765·6	612	294166	1922·7	662	344196	2079·7	712	398153	2236·8
513	206692	1611·6	563	248947	1768·7	613	295128	1925·8	663	345237	2082·9	713	399272	2240·0
514	207499	1614·8	564	249832	1771·9	614	296092	1928·9	664	346279	2086·0	714	400393	2243·1
515	208307	1617·9	565	250719	1775·0	615	297057	1932·1	665	347323	2089·2	715	401515	2246·2
516	209117	1621·1	566	251607	1778·1	616	298024	1935·2	666	348368	2092·3	716	402639	2249·4
517	209928	1624·2	567	252497	1781·3	617	298992	1938·4	667	349415	2095·4	717	403765	2252·5
518	210741	1627·3	568	253388	1784·4	618	299962	1941·5	668	350464	2098·6	718	404892	2255·7
519	211556	1630·5	569	254281	1787·6	619	300934	1944·7	669	351514	2101·7	719	406020	2258·8
520	212372	1633·6	570	255176	1790·7	620	301907	1947·8	670	352565	2104·9	720	407150	2261·9
521	213189	1636·8	571	256072	1793·9	621	302882	1950·9	671	353618	2108·0	721	408282	2265·1
522	214008	1639·9	572	256970	1797·0	622	303858	1954·1	672	354673	2111·2	722	409416	2268·2
523	214829	1643·1	573	257869	1800·1	623	304836	1957·2	673	355730	2114·3	723	410550	2271·4
524	215651	1646·2	574	258770	1803·3	624	305815	1960·4	674	356788	2117·4	724	411687	2274·5
525	216475	1649·3	575	259672	1806·4	625	306796	1963·5	675	357847	2120·6	725	412825	2277·7
526	217301	1652·5	576	260576	1809·6	626	307779	1966·6	676	358908	2123·7	726	413965	2280·8
527	218128	1655·6	577	261482	1812·7	627	308763	1969·8	677	359971	2126·9	727	415106	2283·9
528	218956	1658·8	578	262389	1815·8	628	309748	1972·9	678	361035	2130·0	728	416248	2287·1
529	219787	1661·9	579	263298	1819·0	629	310736	1976·1	679	362101	2133·1	729	417393	2290·2
530	220618	1665·0	580	264208	1822·1	630	311725	1979·2	680	363168	2136·3	730	418539	2293·4
531	221452	1668·2	581	265120	1825·3	631	312715	1982·4	681	364237	2139·4	731	419686	2296·5
532	222287	1671·3	582	266033	1828·4	632	313707	1985·5	682	365308	2142·6	732	420835	2299·7
533	223123	1674·5	583	266948	1831·6	633	314700	1988·6	683	366380	2145·7	733	421986	2302·8
534	223961	1677·6	584	267865	1834·7	634	315696	1991·8	684	367453	2148·9	734	423138	2305·9
535	224801	1680·8	585	268783	1837·8	635	316692	1994·9	685	368528	2152·0	735	424292	2309·1
536	225642	1683·9	586	269703	1841·0	636	317690	1998·1	686	369605	2155·1	736	425447	2312·2
537	226484	1687·0	587	270624	1844·1	637	318690	2001·2	687	370684	2158·3	737	426604	2315·4
538	227329	1690·2	588	271547	1847·3	638	319692	2004·3	688	371764	2161·4	738	427762	2318·5
539	228175	1693·3	589	272471	1850·4	639	320695	2007·5	689	372845	2164·6	739	428922	2321·6
540	229022	1696·5	590	273397	1853·5	640	321699	2010·6	690	373928	2167·7	740	430084	2324·8
541	229871	1699·6	591	274325	1856·7	641	322705	2013·8	691	375013	2170·8	741	431247	2327·9
542	230722	1702·7	592	275254	1859·8	642	323713	2016·9	692	376099	2174·0	742	432412	2331·1
543	231574	1705·9	593	276184	1863·0	643	324722	2020·0	693	377187	2177·1	743	433578	2334·2
544	232428	1709·0	594	277117	1866·1	644	325733	2023·2	694	378276	2180·3	744	434746	2337·3
545	233283	1712·2	595	278051	1869·3	645	326745	2026·3	695	379367	2183·4	745	435916	2340·5
546	234140	1715·3	596	278986	1872·4	646	327759	2029·5	696	380459	2186·6	746	437087	2343·6
547	234998	1718·5	597	279923	1875·5	647	328775	2032·6	697	381554	2189·7	747	438259	2346·8
548	235858	1721·6	598	280862	1878·7	648	329792	2035·8	698	382649	2192·8	748	439433	2349·9
549	236720	1724·7	599	281802	1881·8	649	330810	2038·9	699	383746	2196·0	749	440609	2353·1
550	237583	1727·9	600	282743	1885·0	650	331831	2042·0	700	384845	2199·1	750	441786	2356·2

AREAS AND CIRCUMFERENCES OF CIRCLES.
751 TO 999.

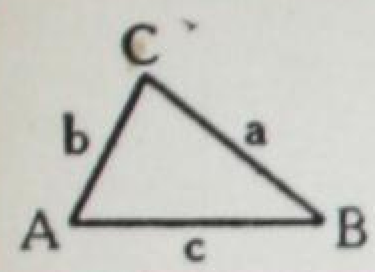
Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.	Diameter	Area.	Circumference.
751	442965	2359·3	801	503912	2516·4	851	568786	2673·5	901	637587	2830·6	951	710315	2987·7
752	444146	2362·5	802	505171	2519·6	852	570124	2676·6	902	639003	2833·7	952	711809	2990·8
753	445328	2365·6	803	506432	2522·7	853	571463	2679·8	903	640421	2836·9	953	713306	2993·9
754	446511	2368·8	804	507694	2525·8	854	572803	2682·9	904	641840	2840·0	954	714803	2997·1
755	447697	2371·9	805	508958	2529·0	855	574146	2686·1	905	643261	2843·1	955	716303	3000·2
756	448883	2375·0	806	510223	2532·1	856	575490	2689·2	906	644683	2846·3	956	717804	3003·4
757	450072	2378·2	807	511490	2535·3	857	576835	2692·3	907	646107	2849·4	957	719306	3006·5
758	451262	2381·3	808	512758	2538·4	858	578182	2695·5	908	647533	2852·6	958	720810	3009·6
759	452453	2384·5	809	514028	2541·5	859	579530	2698·6	909	648960	2855·7	959	722316	3012·8
760	453646	2387·6	810	515300	2544·7	860	580880	2701·8	910	650388	2858·8	960	723823	3015·9
761	454841	2390·8	811	516573	2547·8	861	582232	2704·9	911	651818	2862·0	961	725332	3019·1
762	456037	2393·9	812	517848	2551·0	862	583585	2708·1	912	653250	2865·1	962	726842	3022·2
763	457234	2397·0	813	519124	2554·1	863	584940	2711·2	913	654684	2868·3	963	728354	3025·4
764	458434	2400·2	814	520402	2557·3	864	586297	2714·3	914	656118	2871·4	964	729867	3028·5
765	459635	2403·3	815	521681	2560·4	865	587655	2717·5	915	657555	2874·6	965	731382	3031·6
766	460837	2406·5	816	522962	2563·5	866	589014	2720·6	916	658993	2877·7	966	732899	3034·8
767	462041	2409·6	817	524245	2566·7	867	590375	2723·8	917	660433	2880·8	967	734417	3037·9
768	463247	2412·7	818	525529	2569·8	868	591738	2726·9	918	661874	2884·0	968	735937	3041·1
769	464454	2415·9	819	526814	2573·0	869	593102	2730·0	919	663317	2887·1	969	737458	3044·2
770	465663	2419·0	820	528102	2576·1	870	594468	2733·2	920	664761	2890·3	970	738981	3047·3
771	466873	2422·2	821	529391	2579·2	871	595835	2736·3	921	666207	2893·4	971	740506	3050·5
772	468085	2425·3	822	530681	2582·4	872	597204	2739·5	922	667654	2896·5	972	742032	3053·6
773	469298	2428·5	823	531973	2585·5	873	598575	2742·6	923	669103	2899·7	973	743559	3056·8
774	470513	2431·6	824	533267	2588·7	874	599947	2745·8	924	670554	2902·8	974	745088	3059·9
775	471730	2434·7	825	534562	2591·8	875	601320	2748·9	925	672006	2906·0	975	746619	3063·1
776	472948	2437·9	826	535858	2595·0	876	602696	2752·0	926	673460	2909·2	976	748151	3066·2
777	474168	2441·0	827	537157	2598·1	877	604073	2755·2	927	674915	2912·3	977	749685	3069·3
778	475389	2444·2	828	538456	2601·2	878	605451	2758·3	928	676372	2915·4	978	751221	3072·5
779	476612	2447·3	829	539758	2604·4	879	606831	2761·5	929	677831	2918·5	979	752758	3075·6
780	477836	2450·4	830	541061	2607·5	880	608212	2764·6	930	679291	2921·7	980	754296	3078·8
781	479062	2453·6	831	542365	2610·7	881	609595	2767·7	931	680752	2924·8	981	755837	3081·9
782	480290	2456·7	832	543671	2613·8	882	610980	2770·9	932	682216	2928·0	982	757378	3085·0
783	481519	2459·9	833	544979	2616·9	883	612366	2774·0	933	683680	2931·1	983	758922	3088·2
784	482750	2463·0	834	546288	2620·1	884	613754	2777·2	934	685147	2934·2	984	760466	3091·3
785	483982	2466·2	835	547599	2623·2	885	615143	2780·3	935	686615	2937·4	985	762013	3094·5
786	485216	2469·3	836	548912	2626·4	886	616534	2783·5	936	688084	2940·5	986	763561	3097·6
787	486451	2472·4	837	550226	2629·5	887	617927	2786·6	937	689555	2943·7	987	765111	3100·8
788	487688	2475·6	838	551541	2632·7	888	619321	2789·7	938	691028	2946·8	988	766662	3103·9
789	488927	2478·7	839	552858	2635·8	889	620717	2792·9	939	692502	2950·0	989	768214	3107·0
790	490167	2481·9	840	554177	2638·9	890	622114	2796·0	940	693978	2953·1	990	769769	3110·2
791	491409	2485·0	841	555497	2642·1	891	623513	2799·2	941	695455	2956·2	991	771325	3113·3
792	492652	2488·1	842	556819	2645·2	892	624913	2802·3	942	696934	2959·4	992	772882	3116·5
793	493897	2491·3	843	558142	2648·4	893	626315	2805·4	943	698415	2962·5	993	774441	3119·6
794	495143	2494·4	844	559467	2651·5	894	627718	2808·6	944	699897	2965·7	994	776002	3122·7
795	496391	2497·6	845	560794	2654·6	895	629124	2811·7	945	701380	2968·8	995	777564	3125·9
796	497641	2500·7	846	562122	2657·8	896	630530	2814·9	946	702865	2971·9	996	779128	3129·0
797	498892	2503·8	847	563452	2660·9	897	631938	2818·0	947	704352	2975·1	997	780693	3132·2
798	500145	2507·0	848	564783	2664·1	898	633348	2821·2	948	705840	2978·2	998	782260	3135·3
799	501399	2510·1	849	566116	2667·2	899	634760	2824·3	949	707330	2981·4	999	783828	3138·5
800	502656	2513·3	850	567450	2670·4	900	636173	2827·4	950	708822	2984·5			

PROPERTIES OF VARIOUS FIGURES.

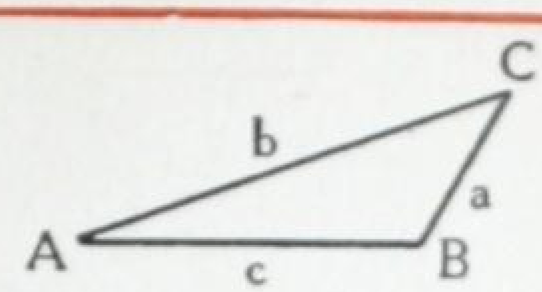
SECTION.								
Area.	A	bd	$BD-bd$	B^2	$\frac{bd}{2}$	$\frac{(B+b)d}{2}$	$\frac{\pi d^2}{4}$	$\frac{\pi}{4}(D^2-d^2)$
Moment of Inertia.	I	$A\frac{d^2}{12}$	$\frac{BD^3-bd^3}{12}$	$A\frac{B^2}{12}$	$A\frac{d^2}{18}$	$\frac{(B+b)^2+2Bb}{36(B+b)}d^3$	$A\frac{d^2}{16}$	$A\frac{D^2+d^2}{16}$
Distance of Neutral Axis.	n	$\frac{d}{2}$	$\frac{D}{2}$	$\frac{B}{\sqrt{2}}$	$\frac{2}{3}d$	$\frac{(b+2B)d}{3(B+b)}$	$\frac{d}{2}$	$\frac{D}{2}$
Section Modulus.	M	$A\frac{d}{6}$	$\frac{I}{n}$	$A\frac{\sqrt{2}B}{12}$	$A\frac{d}{12}$	$\frac{I}{n}$	$A\frac{d}{8}$	$A\frac{D^2+d^2}{8D}$
Radius of Gyration.	g	$\frac{d}{\sqrt{12}}$	$\sqrt{\frac{I}{A}}$	$\frac{B}{\sqrt{12}}$	$\frac{d}{\sqrt{18}}$	$\sqrt{\frac{I}{A}}$	$\frac{d}{4}$	$\frac{\sqrt{D^2+d^2}}{4}$

SECTION.						Parabola 	Parabola 	
Area.	A	$\frac{\pi r^2}{4} = \cdot 7854\, r^2$			$r^2\left(1-\frac{\pi}{4}\right)$ $\cdot 2146\, r^2$	$\frac{bd}{3}$	$\frac{2bd}{3}$	$b(D-d)$
Moment of Inertia.	I	$r^4\left(\frac{\pi}{16}-\frac{4}{9\pi}\right)$ $\cdot 0549\, r^4$	$Ar^2\left(\frac{1}{4}-\frac{1}{2\pi}\right)$ $\cdot 0713\, r^4$	$r^4\left(\frac{\pi}{16}+\frac{1}{8}-\frac{8}{9\pi}\right)$ $\cdot 0384\, r^4$	$r^4\left(\frac{1}{3}-\frac{\pi}{16}-\frac{1}{36-9\pi}\right)$ $\cdot 0075\, r^4$	—	—	$\frac{b(D^3-d^3)}{12}$
Distance of Neutral Axis.	n	$r\left(1-\frac{4}{3\pi}\right)$ $\cdot 5756\, r$	$\frac{r}{\sqrt{2}}$ $\cdot 7071\, r$	$r\frac{4\sqrt{2}}{3\pi}$ $\cdot 6002\, r$	$r \div 6\left(1-\frac{\pi}{4}\right)$ $\cdot 7767\, r$	$\frac{3}{4}b$	$\frac{5}{8}b$	$\frac{D}{2}$

The Moment of Inertia (I) is given for the axis shewn on the sketch, which passes through the centre of gravity; the Moment of Inertia for a parallel axis at distance a is $Aa^2 + I$.
The profile of an ordinary steel section is made up of rectangles, triangles and areas bounded by circular arcs; its properties can, therefore, be deduced from the data tabulated above. The properties of the parabola are useful in solving deflection problems.
Moments of Inertia of rectangles are tabulated on pages 254-255.



TRIGONOMETRICAL.



Elementary. Tan = sin/cos; sec = 1/cos; cosec = 1/sin; versin A = 1 — cos A.

Solution of Triangles.

Let $s = \frac{1}{2}(a + b + c)$. Then :—

(i) Given a, b, c, we have :

$$\text{Sin A} = 2\sqrt{\{s(s-a)(s-b)(s-c)\}} \div bc$$

(ii) Given a, b, C, we have :

$$c = \sqrt{(a^2 + b^2 - 2ab.\cos \text{C})}$$
$$\text{Tan A} = a \sin \text{C} \div (b - a \cos \text{C})$$

(iii) Given A, B, C, a, we have :

$$b = a \sin \text{B} / \sin \text{A}$$
$$c = a \sin \text{C} / \sin \text{A}$$

(iv) Given a, b, A, we have :

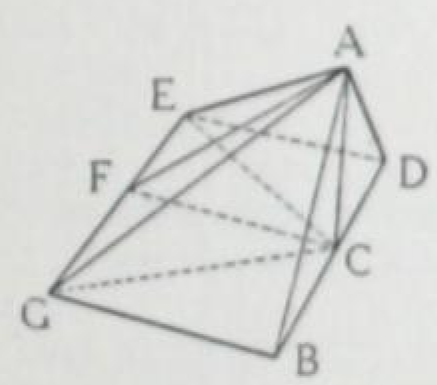
$$\text{Sin B} = b \sin \text{A} / a$$
$$\text{C} = 180° - (\text{A} + \text{B})$$
$$c = a \sin \text{C} / \sin \text{A}$$

[N.B.—When b exceeds a, then B, C, and c are ambiguous.]

Area of Triangle.

The area equals (i) $\frac{1}{2} ab \sin \text{C}$, or $\frac{1}{2} bc \sin \text{A}$, etc., or (ii) $\sqrt{\{s(s-a)(s-b)(s-c)\}}$.

Hip Roofs and Bin Hoppers.



Given that AB = AD, EGB and GBD are 90°, C and F the mid-points of BD and EG,

let h = AC, p = CB / AC and q = CF / AC.

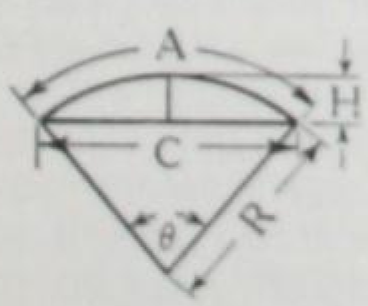
Then we have :—

$$\text{AB, AD} = h\sqrt{(p^2 + 1)}$$
$$\text{AF} = h\sqrt{(q^2 + 1)}$$
$$\text{AG, AE} = h\sqrt{(p^2 + q^2 + 1)}$$
$$\text{Cot AGC} = \sqrt{(p^2 + q^2)}$$
$$\text{Tan AGB} = \sqrt{(p^2 + 1)} \div q$$
$$\text{Tan AGF} = \sqrt{(q^2 + 1)} \div p$$

Let d be the (obtuse) dihedral angle between the planes AGB and AGF (measured square to AG) then we have :—

$$\text{Tan } d = -\sqrt{(p^2 + q^2 + 1)} \div pq$$

Segments and Arcs.



$$\text{R} = (\text{C}^2 + 4\text{H}^2) \div 8\text{H}$$
$$\text{H} = \text{R} - \sqrt{(\text{R}^2 - \tfrac{1}{4}\text{C}^2)}$$
$$\text{A (if C greater than 3H)} = \text{C} + 5\text{H}^2 / 2\text{C, ap rox.}$$
$$\text{Area of segment} = \tfrac{2}{3}\text{CH} + \tfrac{8}{15}\text{H}^3 / \text{C, approx.}$$
$$\text{Tan } \tfrac{1}{4} \text{ angle at centre} = 2\text{H} / \text{C}.$$

The foregoing data have been kindly contributed by Professor C. L. T. Griffith.

INDEX.

Index, Code.

INDEX.—Continued.

INDEX.—Continued.

INDEX.—Continued.

INDEX.—Continued.

TELEGRAPHIC CODE WORDS.

TELEGRAPHIC CODE.

For Summary, see page 349.

1. EXPLANATION.

The code words are mostly selected from Bentley's Code, by arrangement with Mr. E. L. Bentley, 4, Fenchurch Avenue, E.C.3.

Cabled orders for Broad Flange Beams, Grey Process, should always specify *inter alia* the Quality (§ 21) and the Cutting Margin (§ 14). Overseas firms are recommended to arrange with their European correspondents to add to their current code a word signifying "This message contains some code words from R. A. Skelton & Co.'s Handbooks."

2. BEVEL CUTS.

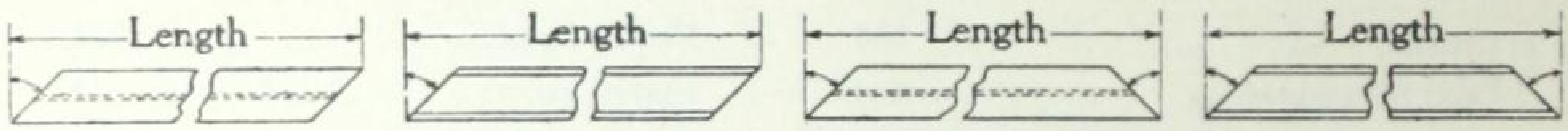


Fig. A   Fig. B   Fig. C   Fig. D

ZABSY	... One end cut on bevel as per Fig. A.	Angle to be......degrees.
ZABUR	... Both ends cut on bevel as per Fig. A.	Angle to be......degrees.
ZACAN	... One end cut on bevel as per Fig. B.	Angle to be......degrees.
ZACEP	... Both ends cut on bevel as per Fig. B.	Angle to be......degrees.
ZACOR	... Ends to be cut on bevel as per Fig. C.	Angle to be......degrees.
ZACTY	... Ends to be cut on bevel as per Fig. D.	Angle to be......degrees.

3. BOLTS AND NUTS.

ZACUS	... $\frac{1}{2}''$ Hex. Rd. Hex.	ZADPA	... 1" Hex. Rd. Hex.
ZACYT	... $\frac{5}{8}''$,, ,, ,,	ZADSO	... With bolts and nuts.
ZADIR	... $\frac{3}{4}''$,, ,, ,,	ZADTE	... Without bolts and nuts.
ZADOS	... $\frac{7}{8}''$,, ,, ,,	ZADUL	... Turned bolts.

4. BROAD FLANGE BEAMS, GREY PROCESS.

ZADVY	... Broad Flange Beams, Grey Process.	
ZAEBY	... ,, ,, ,, ,, ,,	DIE Series (Minimum weights).
ZAEGS	... ,, ,, ,, ,, ,,	DIL Series (Reduced webs).
ZAEHF	... ,, ,, ,, ,, ,,	DIN Series (Medium weights).
ZAEND	... ,, ,, ,, ,, ,,	DIR Series (Maximum weights).
ZAEPI	... ,, ,, ,, ,, ,,	Intermediate weights.
ZAEQT	... ,, ,, ,, ,, ,,	Special Pole sections.
ZAERD	... ,, ,, ,, ,, ,,	with Flange Plates.

[N.B.—Code words for the individual sections will be found on pages 355 and 356.]

5. CAMBER.

ZAEST ... Cambered to a rise (at centre) of......(inches), Fig. A.
ZAETI ... ditto. Fig. B.

Fig. A.

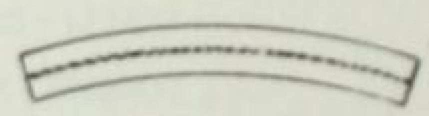


Fig. B.

6. CLEATS.

ZAEUM ... Web cleats at one end.
ZAEVA ... ,, ,, at both ends.

7. DELIVERY.

ZAEWL ... As soon as possible, but at lowest market price (not urgent).
ZAEYN ... Promptly from rolls (fairly urgent).
ZAFAG ... From stock or immediate rolling (very urgent).

For Summary, see page 349.

7. DELIVERY.—Continued.

ZAFER ... From works stock.
ZAFRE ... From stock in the United Kingdom.
ZAGAR ... From receipt of order.
ZAGES ... At rate of......tons weekly, commencing in......weeks.
ZAGVO ... Commencing in......weeks, completing in......weeks.
ZAHIV ... Specification to follow by (or within)......
ZAHSA ... Forward contract, delivery over (during)......

[Refer also to public codes under the headings Delivery, Shipment, etc.]

8. DIMENSIONS.

Useful ranges of dimensions will be found in the public codes. For example, in Bentley's Code, see Numerals, Feet, and Inches.

9. ENQUIRIES.

ZAKUB ... Telegraph to-day's basis price for............
ZAKVA ... „ „ „ „ „ Broad Flange Beams, Grey Process.
ZALCO ... Quote basis price for............
ZALIZ ... Quote (inclusive) price and time of delivery for............
ZALOB ... In Sterling.
ZALUC ... In......(currency).

[Refer also to public codes under the headings Telegraph, Cable, Quote, etc.]

10. FISHPLATES. [See also § 12.]

ZAMOC ... Standard fishplates.
ZAMUD ... With bolts and nuts.
ZAMYA ... With fishplates, bolts and nuts.
ZAMZE ... Slotted holes.
ZANAZ ... At one end.
ZANBE ... At both ends.

11. HANDBOOKS.

ZANDO ... (Refer to) R. A. Skelton & Co.'s Handbook No. (page).
ZANEB ... „ „ „ „ „ „ „ „ No. 21A („).
ZANFO ... „ „ „ „ „ „ „ „ No. 22 („).
ZANGY ... „ „ „ „ „ „ „ List C.

12. HOLES. (See also §§ 10 and 26.)

ZAWAJ ... Holes in webs.
ZAWEK ... Holes in flanges.
ZAWIL ... Ordinary round holes.
ZAWMO ... Oval or slotted holes......″ × ......″
ZAWPY ... Holes......″ diameter.
ZAYAK ... Holes for......″ diameter bolts.

TELEGRAPHIC CODE.—Continued.

For Summary, see page 349.

13. LENGTHS.

These will ordinarily be specified by means of a public code, namely :—

(i) Bentley's Code : refer to " Feet " and " Numerals."
(ii) Western Union Code (5-letter) : " Inches " and " Feet " (p. 1667).
(iii) A.B.C. Code (6th Edition) : " Dimensions."

14. MARGIN IN LENGTHS.

ZECAS ... $\frac{1}{8}$ inch, under and over (both ends square).
ZECET ... $\frac{1}{4}$ inch over, nothing under (both ends square).
ZECIV ... $\frac{1}{4}$ inch under, nothing over (both ends square).
ZECOW ... $\frac{1}{4}$ inch, under and over (one end square).
ZECUX ... $\frac{3}{8}$ inch, under and over.
ZECZY ... 1 inch, under and over.
ZEDBO ... 2 inches, under and over.
ZEDAT ... $1\frac{1}{2}$ inches over, nothing under.
ZEDCU ... 4 inches over, nothing under.
ZEDEV ... Cut square at one end.
ZEDOY ... ,, ,, both ends.

15. NOTCHING.

ZEELD ... Notched at one end.
ZEEMF ... Notched at both ends.
ZEENG ... To fit into............
ZEEPH ... With top surfaces same level.
ZEERK ... With under surfaces same level.

16. NUMBER.

Refer to a public code under the heading " Numerals," or " Quantities."

17. ORDERS.

ZETAL ... Order from............
ZETEM ... Order from R. A. Skelton & Co. Steel & Engineering, Ltd., London.
ZEVEN ... Await further instructions before rolling.
ZEVIP ... ,, ,, ,, ,, shipping.

18. PAINTING.

ZEWNA ... (One) coat(s) of red oxide paint.
ZEWOR ... ,, ,, ,, red lead paint.
ZEWPE ... ,, ,, ,, tar.
ZEWTY ... ,, ,, ,, linseed oil.
ZEWUS ... Galvanized full length.
ZEWYT ... Galvanized portion to be......(feet).

19. PAYMENT.

ZEYSO ... Opening credit at once with......(bankers), with whom please communicate.

20. PLATED SECTIONS.

Code words for plated Broad Flange Beams will be found on page 356.

For Summary, see page 349

21. QUALITY, TESTS AND INSPECTION.

ZIANK ... Standard quality, 26/30 tons tensile.
ZIARN ... Stock quality.
ZICOC ... 28/33 tons tensile.
ZICUD ... To mechanical tests of British Standard Specification 15.
ZIDDO ... British Standard Specification No.......
ZIFBA ... To German Specification St......
ZIFCE ... Open-hearth Steel.
ZIGCA ... Bessemer Basic.
ZIGDE ... „ Acid.
ZIHFE ... Tensile......tons per square inch.
ZIHHO ... Tensile......kilos per square millimetre.
ZIHUJ ... Elastic limit.
ZIJJO ... Minimum elongation......% in......
ZIKGA ... Reduction of area.
ZIKHE ... Phosphorus......% maximum.
ZIKKO ... Sulphur......% maximum.
ZIKMY ... Copper content......%.
ZIKUL ... Tests and inspection by......
ZILAH ... Test certificate to be supplied.
ZILIK ... Quality suitable for......

22. QUOTATIONS.

ZOAGH ... To-day's price (for......) is......(per ton of 2,240 lb.).
ZOAHJ ... To-day's price for Broad Flange Beams, Grey Process, is......(per ton of 2,240 lb.) basis.

[Refer also to public codes under the headings Quotation, Estimate, etc.]

23. RIVETS.

ZOARS ... Countersunk rivets.
ZOAST ... Rivet pitch.
ZOBCA ... Riveted on arrival.
ZOBDE ... Riveted before dispatch.
ZOCAD ... Rivets packed in cases.
ZOCEF ... Rivets packed in bags.
ZOCIG ... Field rivets.
ZODOJ ... $\frac{1}{2}''$ rivets.
ZODUK ... $\frac{5}{8}''$ rivets.
ZODYL ... $\frac{3}{4}''$ rivets.
ZOEBD ... $\frac{7}{8}''$ rivets.
ZOECF ... 1" rivets.

For Summary, see page 349

24. SEPARATORS, ETC.

ZOELN ... Separator(s).
ZOEMP ... Separators, bolts, and nuts.
ZOERT ... Composed of two......with separators.
ZOEVY ... Composed of three......with separators.

25. SHIPMENT. (See "Delivery," page 350.)

26. STANCHIONS.

ZOGHA ... Holding-down bolts.
ZOGIK ... Holes for holding-down bolts.
ZOGJE ... Shipped with bases riveted (welded) on.
ZOGLO ... Bases shipped separate.
ZOGNY ... Knocked down for shipment.
ZOGOL ... Splice plates.
ZOGUM ... Riveted base(s).
ZOGYN ... Welded base(s).
ZOHAJ ... Standard cap(s), "light" pattern
ZOHEK ... Standard cap(s), "heavy" pattern.

27. STRAIGHTENING.

ZOHIL ... Cold straightened.
ZOHJA ... Usual mill finish.

28. WEIGHT.

[Useful code words will be found in the public codes under Weights, Tons, Cwts., and Numerals.]

ZOHKE ... Rolled to......lb. per foot.

CODE WORDS FOR SECTIONS:

BROAD FLANGE BEAMS, GREY PROCESS.

See also notes on p. 350.

DIE Series (Minimum weights).		DIL Series (Reduced webs).		DIN Series (Medium weights).		DIR Series (Maximum weights).	
Code Word.	Nominal Size.	Code Word.	Nominal Size.	Code Word.	Nominal Size.	Code Word.	Nominal Size.
	Inches. Lb.		Inches. Lb.		Inches. Lb.		Inches. Lb.
YOOPO	4 × 4 × 11	BEAHL	4 × 4 × 14¼	BAABA	4 × 4 × 15	YOACH	4 × 4 × 23
YOOPT	5 × 5 × 13¼	BEANY	5 × 5 × 17	BAANG	5 × 5 × 18	YOADS	5 × 5 × 28
YOORY	5½ × 5½ × 16½	BEBMO	5½ × 5½ × 21	BABAD	5½ × 5½ × 23	YOAGM	5½ × 5½ × 48
YOOSH	6 × 6 × 17½	BEBYP	6 × 6 × 23	BABEF	6 × 6 × 25	YOAGT	6 × 6 × 51
YOOTU	6¼ × 6¼ × 20	BECAK	6¼ × 6¼ × 26	BABHO	6¼ × 6¼ × 31	YOAHN	6¼ × 6¼ × 56
YOOVI	7 × 7 × 25	BEDEM	7 × 7 × 32	BACGE	7 × 7 × 35	YOAJP	7 × 7 × 63
YOOWO	8 × 8 × 30	BEIZK	8 × 8 × 38	BACYL	8 × 8 × 44	YOAMS	8 × 8 × 72
YOOXS	8½ × 8½ × 34½	BERBE	8½ × 8½ × 45	BADOK	8½ × 8½ × 48	YOANT	8½ × 8½ × 79
YOOZA	9½ × 9½ × 41	BETAC	9½ × 9½ × 52	BAEJM	9½ × 9½ × 59	YOARY	9½ × 9½ × 92
YOPAJ	10 × 10 × 44	BETDE	10 × 10 × 56	BAELP	10 × 10 × 61	YOASZ	10 × 10 × 103
YOPBI	10¼ × 10¼ × 46	BETJY	10¼ × 10¼ × 59	BAEZD	10¼ × 10¼ × 64	YOAWD	10¼ × 10¼ × 116
YOPEF	11 × 11 × 51½	BETYJ	11 × 11 × 68	BAHEL	11 × 11 × 76	YOBAH	11 × 11 × 135
YOPGA	12 × 12 × 59	BEVEF	12 × 12 × 76	BAKEN	12 × 12 × 81	YOBIK	12 × 12 × 158
YOPHO	12½ × 12 × 66	BEVHO	12½ × 12 × 81	BAKIP	12½ × 12 × 90	YOBJE	12½ × 12 × 166
YOPIN	13½ × 12 × 71	BEVIG	13½ × 12 × 86	BAKMA	13½ × 12 × 92	YOBLO	13½ × 12 × 168
YOPJU	14 × 12 × 76	BEVKY	14 × 12 × 91	BALEP	14 × 12 × 101	YOBUM	14 × 12 × 170
YOPLY	15 × 12 × 81	BEVUJ	15 × 12 × 96	BALRO	15 × 12 × 102	YOBYN	15 × 12 × 172
YOPOC	16 × 12 × 85	BEWAF	16 × 12 × 101	BALUS	16 × 12 × 110	YOCAJ	16 × 12 × 172
YOPPE	17 × 12 × 90	BEWEG	17 × 12 × 107	BALYT	17 × 12 × 112	YOCEK	17 × 12 × 175
YOPUB	18 × 12 × 96	BEWYL	18 × 12 × 113	BAMAP	18 × 12 × 122	YOCIL	18 × 12 × 175
YORAF	19 × 12 × 102	BEYFS	19 × 12 × 119	BAMIR	19 × 12 × 124	YOCYP	19 × 12 × 178
YORBO	20 × 12 × 108	BEYHE	20 × 12 × 125	BAMOS	20 × 12 × 135	YODAK	20 × 12 × 180
YORCE	22 × 12 × 113	BEYIJ	22 × 12 × 132	BAMUT	22 × 12 × 139	YODEL	22 × 12 × 185
YOREJ	24 × 12 × 124	BEYKO	24 × 12 × 141	BANRE	24 × 12 × 152	YODNO	24 × 12 × 191
YORFU	26 × 12 × 128	DIH Series (extra wide).		BAORY	26 × 12 × 157	YODUP	26 × 12 × 196
YORHI	28 × 12 × 141	YUDOS	3¾ × 5 × 13½	BAOSZ	28 × 12 × 171	YOECK	28 × 12 × 201
YORIL	30 × 12 × 145	YUDPA	4½ × 6 × 16	BAVZE	30 × 12 × 176	YOEGN	30 × 12 × 207
YORKA	32 × 12 × 159	YUDUT	5¼ × 6¾ × 19	BAWIC	32 × 12 × 180	YOELS	32 × 12 × 212
YOROD	34 × 12 × 174	YUDVY	5½ × 7 × 20½	BAWOD	34 × 12 × 196	YOEMT	34 × 12 × 218
YORPY	36 × 12 × 179	YUEGS	6 × 7½ × 23	BAWUF	36 × 12 × 201	YOENV	36 × 12 × 223
YORUJ	38 × 12 × 183	YUEMZ	6¾ × 8 × 27	BAWZA	38 × 12 × 206	YOERZ	38 × 12 × 229
YOSAN	40 × 12 × 188	YUERF	7½ × 8¾ × 33	BAYEC	40 × 12 × 211	YOEVD	40 × 12 × 234

For other dimensions and properties, see pages 16-20 (for the DIH sections, p. 20).

CODE WORDS FOR SECTIONS.—Cont'd.

BROAD FLANGE BEAMS, GREY PROCESS.

See also notes on p. 350.

Intermediate weights.

Code Word.	Section.	Weight per ft.	Code Word.	Section.	Weight per ft.
	Ins.	Lb.		Ins.	Lb.
YOFLA	5½	29·2	YOKUV	11	105·0
YOFME	5½	35·3	YOKWY	11	119·0
YOFOP	5½	41·5	YOLAR	12	100·0
YOFYR	6	31·3	YOLIT	12	120·0
YOGAM	6	37·9	YOLOV	12	138·0
YOGEN	6	44·5	YOLRA	12½	110·0
YOGIP	6¼	36·7	YOLSE	12½	128·0
YOGSY	6¼	41·9	YOLVO	12½	148·0
YOGUR	6¼	48·0	YOLYX	13½	111·0
YOGYS	7	41·4	YOMAS	13½	130·0
YOHAN	7	47·2	YOMET	13½	150·0
YOHEP	7	54·0	YOMIV	14	123·0
YOHOR	8	51·0	YOMUX	14	145·0
YOHPE	8	57·5	YOMWO	15	124·0
YOHTY	8	65·1	YOMZY	15	147·0
YOHUS	8½	56·2	YONAT	16	132·0
YOHYT	8½	63·3	YONEV	16	155·0
YOIKS	8½	71·6	YONOY	17	134·0
YOILT	9½	67·6	YONUZ	17	157·0
YOIPY	9½	75·3	YONVE	18	140·0
YOIRB	9½	84·4	YONYO	18	157·0
YOJAP	10	71·7	YOOHR	19	141·0
YOJIR	10	82·5	YOOJS	19	160·0
YOJOS	10	91·9	YOOKT	20	158·0
YOJUT	10¼	76·1	YOOLV	22	163·0
YOJVY	10¼	90·0	YOONY	24	171·0
YOKER	10¼	103·0	YOOPZ	26	176·0
YOKTO	11	90·5	...	...	...

For further details of sections, see pages 16–20.

For specifying intermediate weights other than the above, use the code word for the DIN weight, followed by the code word ZOHKE (meaning " Rolled to......lb. per foot ").

American Sizes.

YUMAY	...	6″ × 6″
YUMCO	...	8″ × 8″
YUMEZ	...	10″ × 10″
YUMIB	...	12″ × 12″
YUMOC	...	14″ × 12″

The above code words to be followed by the weight per foot.

DIN weights, Plated.

Code Word.	Section.	Plates.
	Ins.	Ins.
BOJOF	8½	10×½
BOJUG	8½	10×⅝
BOJYH	8½	10×¾
BOKAC	8½	10×1
BOPOL	9½	12×½
BOPUM	9½	12×⅝
BOPYN	9½	12×¾
BORAK	9½	12×1
BOREL	10	12×½
BORKA	10	12×⅝
BORLE	10	12×¾
BORNO	10	12×1
BORUP	10¼	12×½
BOSAL	10¼	12×⅝
BOSME	10¼	12×¾
BOSPO	10¼	12×1
BOVYT	11	12×½
BOWAP	11	12×⅝
BOWIR	11	12×¾
BRISF	11	12×1
BUKIK	12	14×½
BUKJE	12	14×⅝
BUKLO	12	14×¾
BUKNY	12	14×1
BUKUM	12	14×1⅛
BUKYN	12	14×1¼
...	...	...
...	...	...
...	...	...

ts,

Plates.
Ins.
$10 \times \frac{1}{2}$
$10 \times \frac{5}{8}$
$10 \times \frac{3}{4}$
10×1
$12 \times \frac{1}{2}$
$12 \times \frac{5}{8}$
$12 \times \frac{3}{4}$
12×1
$12 \times \frac{1}{2}$
$12 \times \frac{5}{8}$
$12 \times \frac{3}{4}$
12×1
$12 \times \frac{1}{2}$
$12 \times \frac{5}{8}$
$12 \times \frac{3}{4}$
12×1
$12 \times \frac{1}{2}$
$12 \times \frac{5}{8}$
$12 \times \frac{3}{4}$
12×1
$14 \times \frac{1}{2}$
$14 \times \frac{5}{8}$
$14 \times \frac{3}{4}$
14×1
$14 \times 1\frac{1}{8}$
$14 \times 1\frac{1}{4}$
...
...
...